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NANTICOKE WATER CHEMISTRY

SUMMARY REPORT
1969-1978



Ontario

Ministry
of the
Environment



The Honourable
Harry C. Parrott, D.D.S.,
Minister

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NANTICOKE WATER CHEMISTRY

1969-1978

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November, 1979

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INTRODUCTION

The chief aim of the water chemistry program at Nanticoke to date has been the determination of the baseline water quality, against which the effects of industrialization and municipal growth can be measured. The program has also included the determination of areal variability, seasonal cycles and year-to-year trends.

The relationships among the water quality variables and other features, such as currents, phytoplankton, industrial development and so on will be touched on only slightly in this report. A fuller discussion of such relationships will be given in the Nanticoke summary report for the years 1969 to 1978. In effect, this report will serve as a technical appendix to the summary report.

Before discussing the actual results of the surveys from 1969 to 1978, it is necessary to consider the sample collection, analytical methodology and precision and accuracy of the results, especially as long-term trends over ten years are to be examined.

COLLECTION, PRESERVATION AND ANALYSIS OF SAMPLES

The required density of sampling stations, such that each station provided unique information and did not duplicate the results from other stations, was determined in a preliminary study (Palmer, 1968). The chief conclusions reached were that the stations should be spaced about 2 miles apart and that they should be sampled on the same day, preferably within a few hours of each other. Eight stations were eventually selected and have been used for the duration of the study. The locations of stations sampled by the Ministry of the Environment are given in Figure 1a. Station 1040 was established in 1971 to monitor the effects of the Ontario Hydro thermal power plant. Because of the construction of the Stelco loading pier in 1974 and 1975, station 1008 was discontinued in August 1975, being replaced by stations 1041 and 1042, located on

either side of the pier, in May of the same year. In 1978, stations 1085, 1086 and 1087 were added close to Centre Creek, which will serve to carry the effluent from the Stelco works to the lake. Table 1 summarizes station information and gives the depths at which the samples were collected each year.

Table 2 lists the parameters measured in each study year and the number of cruises on which they were measured.

After collection, the samples were taken to the MOE laboratories in Toronto for analysis. Temperature, oxygen and Secchi disk depth were measured in the field. In the earlier years, pH (1969-1972) and conductivity (1970-1972) were also measured in the field.

The methods of sample collection and analysis and the techniques used in maintaining data quality by the Ministry of Environment laboratories are given in several publications (Laboratory Services Branch, 1975; King and Fellin, 1976; Fellin and King, 1976). These reports also list the detection criteria and limits and the within- and between-run analytical precision for various parameters. The values given in these reports apply, strictly speaking, only to 1975. Nevertheless, to give the reader an idea of the quality of the data used in this report, the estimated precision as well as the detection criteria are given in Table 3. Other unpublished reports from the Laboratory Services Branch indicate that, except for a few parameters, no significant analytical biases exist among the different Ministry of Environment laboratories.

The numbers in Table 3 represent the precision that can be expected in the chemical analyses of samples. Additional errors, generally of a magnitude larger than the analytical precision, can arise during collection, transport and preliminary processing and preservation of the samples. In addition, systematic errors can arise through the choice of inappropriate analytical methods or through unsuspected problems with a method such as contaminated wash water, leaching from filter papers or interference by other

dissolved substances, and so on. Thus, analytical precision is not the most important governing factor in determining the uncertainty inherent in the reported values for chemical parameters. As the numbers in Table 3 represent the minimum errors achievable, these numbers can be of assistance in interpreting the results only if analytical effects are limiting, which is seldom the case.

It is difficult to determine the quality of data sets several years old because field and laboratory records are seldom complete, personnel have changed and mistakes may not turn up until the data are looked at. The user of the data will therefore have to employ judgement in deciding whether seeming anomalies are real effects or due to faulty data. Specific examples are discussed in the section on results in this report.

One way of determining the quality of a particular laboratory as compared to others is through inter-laboratory comparisons. Although many such studies have been carried out among laboratories involved in Great Lakes studies, individual laboratories are not identified in these reports. An exception is a paper by Robertson et al. (1974) dealing with the IFYGL studies. The conclusions drawn in that paper were that systematic biases commonly are present in data sets that arise from determinations carried out in several laboratories due to differences in the analytical methods among the participants, but that the differences in sampling methods probably have a relatively minor effect on the results obtained.

Over the years, the Ministry of the Environment and CCIW inter-comparison data do not, on the whole, show any systematic differences. CCIW, however, achieves a higher accuracy and lower detection limit because the analyses for perishable parameters are done in the field soon after collection and because its analytical methods are tailored for a narrower spread of concentrations (D.M. King, Laboratory Services Branch, 1979, pers. comm.).

In conclusion therefore, it will not be possible to remove all doubts about historical data, but one must live with this fact.

RESULTS

1. Long Term Trends

In most years, water quality parameters were sampled at two depths at deeper stations while, at stations less than 6 m deep a single mid-depth sample was taken (Table 1). Complete data for individual stations and cruises are available in the Nanticoke Water Chemistry reports (Palmer, 1970, 1971, 1972; Polak and Kennedy, 1975; Polak, 1975, 1977, 1978a, 1978b; Heathcote, 1979). Although phytoplankton biomass is not a water quality parameter, it is included where necessary because of the intimate connection between it and the nutrients. The phytoplankton data are from reports by Michalski (1972) and Hopkins (1975, 1979). Table 4a of this summary report represents annual averages over all cruises and all stations, Table 4b standard errors and Table 5a the ten-year averages and standard errors by month for those parameters having six or more years of data. Averages by station are not presented except for turbidity (Table 5b), since two-way analyses of variance (see section on Analysis of Variance) show that the Nanticoke area is spatially homogeneous except with respect to turbidity and Secchi disk depth (95% confidence level). Only five complete years of data are available for Secchi disk depth (Table 2). Original data (the averages for each cruise) were used in all calculations. Note that most samples were collected in the warmer months (April to November), "annual averages" in fact implies data averaged over the collection period only.

Long-term (year-to-year) trends in the data were determined by analysis which assumed linearity of data (Polak, 1978a). The results of this analysis are presented in Table 6, Figures 3a to 3r and Figure 4. In some cases, the assumption of linearity may not be valid, but the time series are not long enough to detect any cyclical trends. Most parameters exhibit an average annual decrease; only 3 (total nitrogen, nitrate + nitrite and phytoplankton densities) show average annual increases. Some parameters do not change significantly from year-to-year (dissolved oxygen, pH, Kjeldahl nitrogen, and water level).

Data from some years are considered less reliable because of possible analytical or preservation difficulties (D. M. King, MOE; personal communication). When these data are removed from the analysis, trends are altered substantially (Figures 3d, 3f, 3h, and Figure 4). In particular, filtered reactive phosphorus (FRP) data for 1969, filtered ammonia data for 1969 and 1970, and nitrate + nitrite data for 1969 to 1972 are questionable. A possible explanation for the nitrate results is that the presence of high concentrations of certain substances, including iron, may poison the cadmium column used to reduce nitrate to nitrite, thereby reducing the recovery by about 25 to 30 percent (D. M. King, Laboratory Services Branch, MOE; pers. comm. 1979). The cadmium column has been replaced since 1976 with a hydrazine method for reducing the nitrate. The other anomalies remain unexplained, although improper sample preservation of the rather perishable nutrient samples is a possibility. The freezing of nutrient samples and use of polystyrene containers was not general until 1971.

When the trend analysis for FRP is performed for 1970 to 1978 only, an almost zero trend is observed instead of a marked decrease (Figure 3h). No changes in total filtered phosphorus, total particulate phosphorus, or total unfiltered phosphorus have been observed in the eastern basin of Lake Erie for the period of 1970 to 1978 (IJC, 1979). Similarly, striking changes occur when the 1969 to 1970 data are omitted from the ammonia analysis: a 17.2 % decrease per year is reduced to 5.9% decrease per year (Figure 3f). Because the period 1969 to 1972 is nearly half the available record, data for nitrate + nitrite were analyzed in two groups, 1969 to 1972 and 1973 to 1978. In this case, the overall 1969 to 1978 trend was a substantial increase. However, when the data are analyzed in two parts, the trend in each is a much smaller increase with a jump in concentration of about 0.06 mg/L occurring between them (Figure 3d).

This changes interpretations placed on the analyses, and indicates that perhaps the only true increasing trend is in phytoplankton densities, while the only parameters to show a marked decreasing trend are Secchi disk depth, chlorophyll a, chloride, conductivity, and turbidity (Figure 4).

The nutrients, phosphorus and nitrogen compounds, apparently show no significant trends. An increase in phytoplankton densities may result in decreased Secchi disk depth, but the associated decreases in chlorophyll a and turbidity are puzzling and cannot be explained at this time. In fact, plots of Secchi disk depth against chlorophyll a show, instead of the expected hyperbolic relationship, only a random scatter. Similarly, there is no observable relationship between phytoplankton biomass and chlorophyll a.

The very small or non-existent trends shown in Table 6 are confirmed by lack of significant trends in the concentrations measured by CCIW close to the same area. The only statistically significant change observable in CCIW results is for filtered reactive phosphorus.

Because CCIW did not collect samples regularly and because of the few stations in the area, only 1970 and 1978 were judged to have sufficient samples to justify comparison with MOE data and to calculate trends with time. Table 7 provides locations for CCIW stations used in this analysis. The surface values (1 m) only were used to calculate the means and standard deviations (Table 8), as the water mass below the thermocline does not correspond to the inshore waters at Nanticoke. In 1970, station 51 (42-45-12N, 80-00-48W) and in 1978, station 28, located on the fringes of the Nanticoke area, were selected. The period covered was the beginning of May to the end of October.

The biggest differences between the CCIW and MOE values are for nitrate and ammonia. The problems with the MOE nitrate analyses have been discussed above. The CCIW ammonia value for 1978 is suspiciously low. Since this parameter was not measured from 1974 to 1977 inclusive, it is not possible to say whether the decline is gradual or sudden; the latter could imply possible analytical or sampling differences.

Chloride decreases probably account for concomitant decreases in conductivity. Bennett (National Water Research Institute, Burlington; unpublished manuscript) has observed that if chloride

loadings (and conductivity) to Lake Erie via the Detroit River remain fairly constant over three years (the flushing time of the lake), significant changes in river discharge volume will be observable three years later as concentration changes in the eastern basin of Lake Erie. Therefore if conductivity and chloride for the years 1970 to 1978 are plotted against the Detroit River flows lagged three years, a linear relationship should be observed, with increasing flow resulting in decreasing concentrations. This is apparent in Figures 5a and 5b.

2. Seasonal Variability

On the basis of 10 years' data, seasonal trends in five key parameters were identified (Figure 2). The data were first converted to dimensionless form by the formula

$$A_r = \frac{A - A_{\min}}{A_{\max} - A_{\min}}$$

where A is the ten year average value for a parameter in any month (Table 5a) and A_{\min} and A_{\max} are average minimum and maximum values for the parameter. Therefore, A_r will vary between 0 and 1, representing the minimum and maximum values for each parameter. As expected, nutrient levels tend to be higher in April or May, dropping to lowest levels in early autumn. Peaks in phytoplankton numbers occur just after nutrient peaks, the lowest levels being in June and late fall (Hopkins, 1979). As the phytoplankton population increases early in the year, nutrient uptake increases and nutrient levels drop. As nitrogen and phosphorus decline, phytoplankton levels drop off again, the process reversing once more in late summer. Like the nutrients, conductivity, turbidity and dissolved oxygen decline to low levels in the late summer and early fall, recovering to a greater or lesser extent toward the end of the year. If turbidity is caused by phytoplankton densities, it should follow the same trend. As it in fact varies in a manner opposite to the phytoplankton and correlates with the suspended solids concentration, and as these results are echoed by year-to-year trends in the data (see above), it is likely that turbidity is caused chiefly by resuspension of inorganic material during spring and fall storms.

These results, which are based on original data, vary in some respects from those presented in the 1978 Nanticoke Water Chemistry report (Heathcote, 1979) which were based on data interpolated to mid-month.

Although trace metals have been measured at Nanticoke since 1972, the early results are of very doubtful quality because proper sample preparation was not used. Starting in 1978, samples have been preconcentrated before analysis twenty-fold by evaporating 100 mL down to five. Table 9 gives a comparison of MOE data with some data obtained nearby in 1967 by CCIW (Weiler and Chawla, 1968). The table also gives the detection limits and precision for trace metal analyses by the MOE laboratories (Laboratory Services Branch, MOE, 1975). Because of the preconcentration step, the values for the limit and precision can, in effect, be divided by 20 for the 1978 Ministry analyses.

The great variability of the data in Table 9 does not allow firm conclusions to be drawn either about the quality of the analyses nor about long-term trends. However, the Ministry analyses, for lead, chromium and mercury and, very likely, cadmium and vanadium, seem relatively high. The normal concentration for mercury in surface waters on Canada is around 0.05 ug/L (Sherbin, 1979; Appendix 7). There is some evidence in the data for increasing concentrations of several metals close to shore, as both the Ministry values and those of CCIW station 19 off the Grand River are higher than those of station 39, which is off the tip of Long Point in over 50 m of water. There is no evidence for concentrations increasing with time.

3. Short-Term Variation

Repeated sampling of water quality parameters was undertaken three times at Nanticoke. In 1968 a study was done to determine optimal spacing of stations for the proposed environmental study (Palmer, 1968). Replicate samples were taken at each of 3 stations over a day. On August 1, 1968, six samples spaced four hours apart were taken from each of

three stations spaced one mile apart. Measured parameters were dissolved oxygen saturation, pH, alkalinity, total phosphate and conductivity. A similar run took place on September 10, 1968 at three different stations, this time spaced two miles apart. Sampling was done five times over nine hours; conductivity was not measured in this run.

The results of a two-way analysis of variance showed that differences were significant only between stations two miles apart. The exception was pH, which showed significant station differences with one-mile spacing but not with two mile spacing. These conflicting data were thought to represent local ionic effects. Time differences were always significant at the 95% level or higher except for conductivity on August 1, 1968.

A second type of repeated monitoring program was carried out at Nanticoke over August 7 to 10, October 10 to 16, and October 19 to 24, 1974 and again over May 28 to June 27, 1975 (Polak, 1975, 1977). An automatic NERA environmental monitoring station sampled at 30 minute intervals at two depths at station 1040 for temperature, conductivity, pH, dissolved oxygen, redox potential and depth.

In general, surface layer changes were greater than those at depth, and average changes over 4 hours were smaller than those over one hour periods. No diurnal periodicities were observed on the basis of time series analysis of each year's data. However, short-term periodicities were detected for conductivity measured from August 7 to 9, 1974 and for temperature, pH, and redox potential for the 1975 results. Common periodicities were found for the latter three parameters and the east-west components of currents in 1975. No periodicity could be explained by lake free oscillations.

4. Statistical Analysis

A. Analysis of Variance

A two-way analysis of variance was performed on the data for selected parameters in 1969 and in each year from 1972 to 1978. The results are consistent: except for isolated instances, data are temporally heterogeneous and spatially homogeneous (95% confidence level). The only regular exceptions to this are turbidity and Secchi disk depth, which show both spatial and temporal variability. This chemical uniformity of stations is understandable in that all stations are within 5 km of shore; they are all "inshore" with respect to the eastern basin of Lake Erie. (Hamdy (1979) reports similar findings for the Nanticoke area. He found that phosphorus compounds, chlorophyll a and conductivity were uniformly distributed in a 5 km-wide band extending 20 km on either side of Nanticoke Creek, throughout the year. A small area at the mouth of Centre Creek (4 km^2), however, showed consistently higher values for those parameters.) Turbidity and Secchi disk depth measurements are perhaps more susceptible to local circulation anomalies (i.e. resuspension events and storms) than are other parameters, and they therefore show more variability overall. Seasonal changes in oxygen content are caused by decreases in solubility with increasing water temperature, and the decay of organic matter. Nutrient concentrations and phytoplankton abundance are, as noted earlier, also interdependent.

B. Cluster Analysis

Another statistical technique, cluster analysis, was used to explore possible differences among stations further. This technique is of use when groupings in a data set are suspected but are not obvious. Working from a matrix of Euclidean distances* between cases, the analysis generates a dendrogram (tree diagram) graphically showing the relationships among cases (stations). Those which are statistically similar will, in theory, form part of the same branch on the tree. Other, less closely related stations will branch off the main stem in

*Euclidean distance is defined as the square root of the sum of squares of differences between cases.

other places. In this analysis, the Biomedical Computer Programs BMDP2M program (Dixon, 1975) was used with average 1978 values for 12 parameters (Secchi disk depth, ammonia, conductivity, total phosphorus, chlorophyll a, turbidity, dissolved phosphorus, chloride, Kjeldahl nitrogen, silicate, nitrate + nitrite, and phytoplankton abundance). Where two depths had been measured, data were averaged over depth. Figure 6 shows the dendrogram obtained from the present analysis. The stations farthest offshore, 112, 648, and 501, form the first major cluster. Fairly closely related to them and different from the remainder of stations are 1086 and 518. Then, forming a third group farther down the main stem are 1087, 1042, 1040, and 810. Finally, stations 994, 1041, 1016 and 1085 vary in a manner different from the preceding groups and do not themselves form a unified group. All of the stations are, however, quite closely related, as is revealed by the very small Euclidean distances (2.004 to 6.915 on a scale of 0 to 100) separating the branches.

C. Discriminant Analysis

As a second stage in pinpointing differences among stations, a discriminant analysis (BMDP7M) was performed on the same data used in the cluster analysis. Discriminant analysis is a form of canonical variate analysis and seeks orthogonal, linear combinations of variables which best separate a priori groupings of cases. In this instance, the stations were divided into two groups: "offshore" (112, 501 and 648) and "inshore" (all others). The results from this analysis showed that the only variables which contributed significantly to group separation were Secchi disk depth and Kjeldahl nitrogen, the latter being of secondary importance. This finding therefore bears out the assumption that the MOE stations form a spatially uniform group with respect to chemical parameters.

In a second stage of the analysis, five CCIW stations (permanent station numbers for 1978: 27, 28, 29, 30, 31; Table 7) were added as a control group; most of these lie farther offshore than do MOE stations. Two seasonal "snapshots" were selected to give precise information about station differences. The spring "snapshot" was represented by surface water data for the MOE cruise of June 5, 1978

and the CCIW cruise of May 30, 1978. A mid-summer "snapshot" was made up of surface water data from the MOE cruise of July 17, 1978 and the CCIW cruise of July 13, 1978. No autumn data were analysed because upwelling is suspected at some stations through September and October, 1978, and if present, would obscure the results of the analysis. In making the discriminant analyses, variables are weighted in such a way that those with the largest variances are used first, followed by all others. Secchi disk depth, dissolved oxygen, total phosphorus, ammonia, nitrate + nitrite, and silica had the largest variances among stations and were added to the analysis first. Temperature, filtered reactive phosphorus and chloride had small variances and were added later, in the expectation that they would contribute little to group separation.

In fact, even the small-variance variables contributed to the separation. In the spring, the variables best separating the groups were Secchi disk depth, silica, temperature, and chloride. In the summer, Secchi disk depth and chloride accounted for most of the between-groups variance.

The discriminant analysis confirmed that phosphorus and nitrogen are as variable between groups of stations as they are within a group. Secchi disk depth separated the groups well in all analyses; silica, chloride, temperature, and Kjeldahl nitrogen probably also play a part, but their importance may vary with time of year and stratification conditions. It is possible that the chloride effect is an artifact of analytic bias between the two laboratories. Overall variation in chloride concentrations is very small, but concentrations at CCIW stations are always higher than those at MOE stations.

CCIW stations always form a group quite distant statistically from all the MOE stations. Inshore and offshore MOE station groups do not overlap but are much closer statistically than either is to the CCIW group (Figure 7). On first inspection, this again supports the assumption that all MOE stations are roughly similar and are

classifiable as one somewhat variable group - the inshore zone. CCIW stations, on the other hand, appear to come from a different zone and demonstrate a number of major differences from the inshore zone; these might therefore be interpreted as an "offshore" group, even though station 31 is close to the shore. It is possible that calculated differences between the CCIW and MOE groups are in fact attributable to differences in analytic techniques between laboratories, as suggested above for chloride measurements.

CONCLUSIONS

All water quality parameters measured at Nanticoke have met the provincial Water Quality Objectives for at least the last five years (1974-78). Those which are closest to maximum allowable levels (the phosphorus compounds) either have not increased, or have shown a decreasing trend. Turbidity, which is apparently mostly attributable to resuspension of inorganic material, has decreased over the sampled period. This may be related to reductions in storm frequency or intensity. Phytoplankton abundance has shown an increasing trend, but this may possibly be due to very high values in 1978 following a 9-year period of little change. The 1977 Nanticoke Water Chemistry Report (Polak, 1978b) states that between 1969 and 1977 phytoplankton biomass declined an average of 0.72% per year, which was not statistically different from zero change. When 1978 data are added to the trend analysis, however, an average 3.9% increase per year is observed. Secchi disk depth has been decreasing (becoming shallower), but while this seems to give credence to the phytoplankton results, the trend is strongly influenced by large values in 1969-71, followed by a 7-year period of little change.

Despite total phosphorus concentrations of around 20 ug/L, the area around Nanticoke and Long Point Bay is the only region in Lake Erie classified as being in the oligotrophic/mesotrophic range on the basis of total phosphorus, chlorophyll a and Secchi depth (Gregor

and Rast, 1979). All other nearshore regions on the north shore range from mesotrophic to eutrophic. Gregor and Rast believe that this fact is a result of the general lake circulation east of Long Point, a drainage basin having a low potential for contributing phosphorus and sediment to the lake and the absence of any major urban area.

In general, results were statistically homogeneous over the sampled area close to shore but showed significant seasonal variations. Only Secchi disk depth and turbidity differed significantly among the stations. Nutrient compounds showed highest values in filtered samples in the spring, decreasing over the summer months as phytoplankton biomass and nutrient uptake increased. Nutrient levels are lowest in early autumn. When phytoplankton biomass declines again in late autumn, the nutrient levels recover once more.

Variations over shorter periods were fairly large and results from continuous monitoring showed that the average changes observed over one hour periods were greater than those over 4 hours.

Cluster analysis revealed that some MOE stations fall into closely-related groups. An offshore group (Stations 112, 501, 648) was separate from another group (1087, 1040, 1042, 810) and the remaining stations were apparently unrelated statistically, either to each other or to one of the two groups.

A discriminant analysis which included five CCIW stations emphasized the homogeneity of MOE stations and the relative difference of sampling results between MOE and CCIW stations. Secchi disk depth and chloride were the most important variables determining the separation of these groups, but reactive silicate, temperature and Kjeldahl nitrogen were also contributory.

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Table 1: Stations and Sampling Depths (metres)

Year	1969	1970 ¹	1971 ¹	1972 ¹	1973	1974	1975	1976	1977	1978	Latitude N	Longitude W	
Station													
112 ²	1/12	5.6	6.4	6.2	1/11	1/12	1/11	1/11	1/11	1/11	42-45-55	80-02-57	
501 ²	1/9	5.1	6.2	6.2	1/11	1/12	1/11	1/12	1/12	1/12	42-45-32	80-06-18	
648 ²	1/7	3.6	4.0	3.5	1/6	1/7	1/6	1/7	1/7	1/7	42-46-50	80-01-30	
518	3	2.8	3.2	2.6	2.5	3	2.5	3	3	3	42-47-18	79-58-40	
810	1/8	3.9	4.4	3.8	1/7	1/8	1/7	1/8	1/8	1/8	42-47-54	80-01-40	
994	1/7	3.0	3.5	3.8	1/7	1/7	1/6	1/7	1/7	1/7	42-46-45	80-08-40	
1008	3	3.0	3.2	3.1	3.4	3					42-47-17	80-04-36	
1016	1/9	4.6	5.1	4.9	1/8.2	1/9	1/9	1/9	1/9	1/9	42-47-28	80-02-48	
1040			2.9	4.0	3	1/3	3	3	3	3	42-48-00	80-02-00	
1041							1/8	1/9	1/9	1/9	42-47-08	80-04-24	
1042							25	2	2	2	42-47-19	80-04-57	
1085											1.5	42-47-17	80-05-50
1086											1/5.5	42-46-50	80-05-55
1087											1/1.5	42-47-10	80-06-27

¹ During these years, samples were taken at "mid-depth". Considerable depth variation occurred from cruise to cruise and the number represents the average.

² These are defined as "off-shore" stations.

Table 2: Reporting Schedule for Water Quality Parameters¹

Year	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
NO OF CRUISES	8	8	8	9	7	10	8	9	8	11
Conductivity	7	x	x	x	x	9	x	7	x	x
Temperature	x	x	x	7	x	x	x	x	x	8
Chloride		2	7	7	x	x	x	7	x	x
Alkalinity	x	7	x					7	6	4
Sulfate					1	4		7	6	3
Fluoride				1	1					
Potassium				1	1		7			
Total Nitrogen					x	9	x			
TON					x	9				
NH ₃	7	x	x	x	x	9	x	7	x	x
NO ₂	7	x	x	x	x	9	x			
NO ₃	7	x	x	x	9	x				
NO ₂ + NO ₃								7	x	x
Total Kjeldahl N	9	7	x	x	x	9	x	7	x	x
Filt. React. Phosphorus	7	x	x	x	x	9	x	7	x	x
Total Phosphorus	7	x	x	x	x	9	x	x	x	x
Reactive Silicate						5	5	7		x
Diss. Oxygen	x	x	x	8			x	7		4
% Oxygen Saturation	x	x	x	7			7	7	2	4
pH	7	7	x	7	x	x	x	7	6	3
COD				1	1					
BOD ₅				2	1			7	5	3
TOC				2	1					
Turbidity	7	x	x	x	x	x	x	x	7	x
Total Solids				2	1					
Dissolved Solids				6		6	x	7	6	
Suspended Solids								7	6	3
Secchi Disk Depth	2	5	7	2	1	x	x	x	x	x
Chlorophyll <u>a</u>	1	1	7	x	3	x	x	x	x	x
Chlorophyll <u>b</u>	1	1	7	x	3	x	x	x		x
Sulfide				1	1					
Cyanide					1					
Boron				2	1					
Cadmium				2	1		7			
Chromium				2	1					4
Lead				2	1		7			4
Copper				1	1		7			4
Mercury				1	1					
Nickel				1	1		7			4
Vanadium				1	1					
Zinc				1	1		7			4
Cobalt										4
Iron				2	x	9	7	7	6	4
Ether Solubles				2						
Phenols	7	5	5	x	6	x	7	7	6	5

¹ Information for all years except 1970 and 1971 was taken from the annual reports on the water chemistry at Nanticoke prepared by the Ministry of the Environment and the Ontario Water Resources Commission. The 1970-1971 information is from "Nanticoke - A Preoperational Report. Vol.2-Water Chemistry" by MOE, supplemented by data from data file for water quality maintained by MOE. The notation "x" indicates that the parameter was reported for all cruises in a year.

Table 3: Precision and Detection Limits for Water Quality Parameters
(From King and Fellin, 1976)
All measurements in mg/L unless otherwise noted.

PARAMETER	PRECISION*	DETECTION CRITERIA
Conductivity	1.5 uS/cm	5 uS/cm
Chloride	0.5	0.08
Total Alkalinity	1	0.6
Sulfate	3	1.3
Fluoride	0.1	0.01
Potassium	0.2	0.6
Total Phosphorus	0.01	0.003
Filt. React. Phosphorus	0.003	0.002
Total Kjeldahl Nitrogen	0.1	0.04
NO ₂ + NO ₃	0.06	0.02
NH ₃	0.01	0.006
Reactive Silicate	0.2	0.12
pH	0.1 SU	No data
BOD ₅	0.5	0.3
COD	15	10
Turbidity	0.7 FTU	0.4 FTU
Suspended Solids	2	1.1
Phenols	1 ug/L	0.6 ug/L
Iron	0.09	0.05

No information is available for the following parameters: chlorophyll, sulfides, cyanides, boron, cadmium, chromium, lead, copper, mercury, nickel, vanadium, zinc, cobalt.

* Precision implies that the difference between 2 results will not exceed 2.77s (where s is the standard deviation based on in-run duplicate samples) more than 5% of the time.

Detection criteria implies that if the substance is absent, a positive result greater than 1.64s (where s is determined for concentrations close to zero) will be obtained 5% of the time.

Detection limit ensures that when the substance is present it will be reported as present 95% of the time if the concentration exceeds 3.29s. Since the limits are twice the criteria they have not been included in the table.

Table 4a: Annual Averages for Water Quality Parameters

	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
Conductivity (umho/cm)	325.6	323.0	312.7	322.6	312.7	308.7	298.4	301.5	304.4	293.1
Temperature (°C)	14.2	15.5	15.2	12.1	16.1	11.7	14.4	12.9	13.2	11.8
Chloride (mg/L)	-	25.3	25.9	24.1	23.6	21.8	22.2	20.9	20.8	20.5
Alkalinity (mg/L CaCO ₃)	113.	96.	96.	-	-	-	-	96.	97.	99.
Sulfate (mg/L)	-	-	-	-	27.	25.	-	25.	25.	26.
Fluoride (mg/L)	-	-	-	0.1	0.1	-	-	-	-	-
Potassium (mg/L)	-	-	-	1.17	-	-	-	-	-	-
Total Nitrogen (mg/L N) ¹	-	-	-	-	0.412	0.445	0.393	-	-	-
TON (mg/L N) ¹	-	-	-	-	0.26	0.28	-	-	-	-
NH ₃ (mg/L N)	0.05	0.06	0.02	0.01	0.02	0.02	0.02	0.01	0.01	0.01
NO ₂ (mg/L N)	0.006	0.004	0.004	0.003	0.005	0.004	0.004	-	-	-
NO ₃ (mg/L N)	0.07	0.06	0.06	0.07	0.12	0.14	0.11	-	-	-
NO ₂ + NO ₃ (mg/L)	-	-	-	-	-	-	-	.167	.112	.174
Total Kjeldahl N (mg/L N) ¹	0.28	0.37	0.29	0.29	0.28	0.30	0.28	0.26	0.27	0.34
Filt. React. Phosphorus (mg/L P)	0.010	0.005	0.005	0.004	0.005	0.007	0.003	0.004	0.005	0.005
Total Phosphorus (mg/L P)	0.021	0.019	0.016	0.014	0.018	0.022	0.015	0.012	0.018	0.014
Reactive Silicate (mg/L)	-	-	-	-	-	0.18	0.26	0.12	-	0.17
Diss. Oxygen (mg/L)	9.84	9.85	10.28	11.00	-	-	9.75	10.01	-	10.94
Diss. Oxygen (% Sat'n)	96.	97	101.	-	-	-	94.	93	106.	97.
pH (S.U.)	8.3	8.2	8.4	8.3	8.2	7.9	8.3	8.4	8.2	8.1
COD (mg/L)	-	-	-	30	20	-	-	-	-	-
BOD ₅ (mg/L)	-	-	-	1.2	0.5	-	-	0.6	0.5	0.2
TOC (mg/L) ²	-	-	-	5.	5.	-	-	-	-	-
Turbidity (FTU)	5.17	3.19	3.57	4.48	4.15	4.01	2.39	3.14	3.63	3.04
Total Solids (mg/L)	-	-	-	203.89	195.56	-	-	-	-	-
Dissolved Solids (mg/L)	-	-	-	178.9	-	205.7	193.9	197.4	197.2	-
Suspended Solids (mg/L)	-	-	-	-	-	-	-	3.2	4.5	2.9
Secchi Disk Depth (m)	5.4	3.1	3.5	2.7	2.5	2.1	2.3	2.4	2.5	2.6
Chlorophyll <u>a</u> (ug/L)	5.4	4.6	1.8	3.0	2.2	1.3	2.8	2.8	1.7	2.4
Chlorophyll <u>b</u> (ug/L)	0.9	1.7	0.3	0.2	0.2	0.1	0.7	0.7	-	0.4
Sulfide (mg/L)	-	-	-	0.2*	0.2*	-	-	-	-	-
Cyanide (simple)	-	-	-	-	0.02	-	-	-	-	-
Boron as B (mg/L)	-	-	-	0.05	0.08	-	-	-	-	-
Cadmium (mg/L)	-	-	-	0.02	0.02	-	0.02	-	-	-
Chromium (mg/L)	-	-	-	0.02	0.02	-	-	-	-	0.03
Lead (mg/L)	-	-	-	0.09*	0.04	-	0.04	-	-	0.04
Copper (mg/L)	-	-	-	0.05	0.05	-	0.05	-	-	0.05
Mercury (ug/L)	-	-	-	0.35*	0.05*	-	-	-	-	-
Nickel (mg/L)	-	-	-	0.07	0.07	-	0.07	-	-	0.07
Vanadium (mg/L)	-	-	-	0.1	0.1	-	-	-	-	-
Zinc (mg/L)	-	-	-	0.05	0.05	-	0.05	-	-	0.05
Cobalt (mg/L)	-	-	-	-	-	-	-	-	-	0.07
Iron (mg/L)	-	-	-	0.14	0.14	0.22	0.16	0.13	0.22	0.08
Ether Solubles (mg/L)	-	-	-	0.07	-	-	-	-	-	-
Phenols (ug/L)	0.	1.	1.	2.*	3.*	1.	1.	1.	1.	1.

* Does not meet either MOE or IJC Water Quality Objectives

- 1 Total Kjeldahl Nitrogen is a measure of all the Nitrogen in the trinegative state and is primarily a measure of nitrogen present in the organic form, but also includes free ammonia, but not nitrate or nitrite.

Organic nitrogen is the difference between total Kjeldahl and ammonia nitrogen.

Total Nitrogen is the sum of nitrite, nitrate and total Kjeldahl nitrogen.

- 2 Total organic carbon is the difference between total carbon and inorganic carbon.

Note: Values for fluoride, reactive silicate in 1976, BOD₅ in 1978, sulfide and most metals (except for lead in 1972, mercury and iron) are at or near their detection limits (D. M. King, MOE; personal communication). Therefore, little significance is attached to their apparent non-compliance with MOE and IJC water quality objectives. The 1972 value for mercury is probably too high to be real, since the range for mercury in natural lake and harbour waters is normally 0.02 to 0.05 ug/L, with the detection limit approximately 0.02 ug/L (D. Russell, MOE mercury laboratory; personal communication). A new automated method for analysis of phenols was adopted in 1974. The effect of this change, if any, on the quality of data after 1973 is unknown.

Table 4b: Standard Errors for Table 4a

	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
Conductivity (umho/cm)	2.2	1.5	1.0	2.4	1.0	1.5	6.1	1.1	0.8	1.5
Temperature (°C)	0.5	0.3	0.3	0.7	0.7	1.1	6.2	0.7	0.9	0.5
Chloride (mg/L)	-	0.8	3.4	0.3	0.4	0.4	0.6	0.1	0.1	0.1
Alkalinity (mg/L CaCO ₃)	4.	96.	1.	-	-	-	-	8.	5.	6.
Sulfate (mg/L)	-	-	-	-	1.	1.	-	0.	0.	0.
Fluoride (mg/L)	-	-	-	0.0	0.0	-	-	-	-	-
Potassium (mg/L)	-	-	-	0.09	-	-	-	-	-	-
Total Nitrogen (mg/L N)	-	-	-	-	0.034	0.046	0.047	-	-	-
TON (mg/L N)	-	-	-	-	0.02	0.03	-	0.02	0.00	0.00
NH ₃ (mg/L N)	0.01	0.01	0.00	0.03	0.00	0.00	0.01	0.02	0.00	0.00
NO ₂ (mg/L N)	0.001	0.001	0.001	0.000	0.000	0.000	0.001	-	-	-
NO ₃ (mg/L N)	0.01	0.01	0.01	0.07	0.12	0.14	0.11	-	-	-
NO ₂ + NO ₃ (mg/L)	-	-	-	-	-	-	-	0.009	0.008	0.010
Total Kjeldahl N (mg/L N)	0.02	0.02	0.02	0.02	0.02	0.03	0.02	0.02	0.02	0.05
Filt. React. Phosphorus (mg/L P)	0.000	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.001	0.001
Total Phosphorus (mg/L P)	0.002	0.002	0.001	0.001	0.003	0.004	0.005	0.002	0.004	0.003
Reactive Silicate (mg/L)	-	-	-	-	-	0.04	0.05	0.02	-	0.02
Diss. Oxygen (mg/L)	0.90	0.14	0.15	0.16	-	-	0.28	0.25	-	-
Diss. Oxygen (% Sat'n)	12.	2.	1.	-	-	-	2.	3.	7.	2.
pH (S.U.)	0.1	0.1	0.1	0.1	0.1	0.3	0.1	0.4	0.1	0.1
COD (mg/L)	-	-	-	0	0	-	-	-	-	-
BOD ₅ (mg/L)	-	-	-	0.3	0.1	-	-	0.1	0.1	0.0
TOC (mg/L) ²	-	-	-	1.	1.	-	-	-	-	-
Turbidity (FTU)	1.24	0.81	0.32	1.59	1.70	1.36	1.64	1.39	2.03	1.29
Total Solids (mg/L)	-	-	-	8.58	8.82	-	-	-	-	-
Dissolved Solids (mg/L)	-	-	-	11.7	-	1.0	4.0	0.6	0.4	-
Suspended Solids (mg/L)	-	-	-	-	-	-	-	1.5	1.6	1.2
Secchi Disk Depth (m)	2.1	1.1	1.3	0.9	1.8	0.4	0.8	0.8	0.8	0.7
Chlorophyll a (ug/L)	0.0	4.0	0.2	1.1	0.4	0.2	0.4	0.3	0.4	0.3
Chlorophyll b (ug/L)	0.0	0.7	0.1	0.1	0.1	0.0	0.1	0.1	-	0.1
Sulfide (mg/L)	-	-	-	0.0	0.0	-	-	-	-	-
Cyanide (simple)	-	-	-	-	0.00	-	-	-	-	-
Boron as B (mg/L)	-	-	-	0.01	0.03	-	-	-	-	-
Cadmium (mg/L)	-	-	-	0.00	0.00	-	0.00	-	-	-
Chromium (mg/L)	-	-	-	0.00	0.00	-	-	-	-	0.02
Lead (mg/L)	-	-	-	0.00	0.01	-	0.00	-	-	0.01
Copper (mg/L)	-	-	-	0.00	0.03	-	0.01	-	-	0.00
Mercury (ug/L)	-	-	-	0.23	0.00	-	-	-	-	-
Nickel (mg/L)	-	-	-	0.00	0.00	-	0.01	-	-	0.01
Vanadium (mg/L)	-	-	-	0.03	0.00	-	-	-	-	-
Zinc (mg/L)	-	-	-	0.01	0.06	-	0.02	-	-	0.00
Cobalt (mg/L)	-	-	-	-	-	-	-	-	-	0.02
Iron (mg/L)	-	-	-	0.06	0.05	0.08	0.06	0.05	0.11	0.03
Ether Solubles (mg/L)	-	-	-	0.04	-	-	-	-	-	-
Phenols (ug/L)	0.	0.	0.	1.	1.	0.	0.	0.	0.	0.

Table 5a: Ten-Year Mean Monthly Values

Parameter	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.
Conductivity	311.5 (14.6)	308.5 (11.1)	310.4 (12.0)	310.6 (12.7)	306.6 (12.2)	307.9 (13.1)	311.0 (11.5)	317.3 (7.1)	312.9 (12.2)
Chloride	21.8 (2.0)	23.0 (4.0)	22.3 (2.4)	22.3 (2.0)	22.8 (1.4)	22.0 (2.0)	22.4 (1.7)	22.6 (1.2)	22.8* -
Total Nitrogen	.458 (.052)	.460 (.068)	.383 (.066)	.431 (.059)	.360 (.122)	.353 (.075)	.414 (.101)	.433 (.065)	.341* -
NH ₃	0.03 (.03)	.02 (.01)	.03 (.03)	.03 (.02)	.02 (.02)	.02 (.01)	.03 (.04)	.03 (.02)	.03 (.01)
NO ₂ + NO ₃	.172 (.050)	.169 (.067)	.109 (.057)	.120 (.052)	.063 (.038)	.061 (.043)	.130 (.075)	.124 (.037)	.053 (.075)
Kjeldahl Nitrogen	.27 (.06)	.29 (.05)	.28 (.05)	.33 (.05)	.29 (.10)	.29 (.05)	.29 (.06)	.31 (.07)	.30 (.04)
Total Phosphorus	.016 (.006)	.017 (.007)	.015 (.004)	.017 (.004)	.015 (.005)	.016 (.007)	.014 (.005)	.020 (.004)	.028** (.006)
Filt.React.Phosphorus	.005 (.003)	.005 (.003)	.005 (.002)	.006 (.005)	.004 (.002)	.005 (.003)	.004 (.002)	.007 (.005)	.010 (.004)
Dissolved Oxygen (%)	98 (5.)	108. (9.)	105. (10.)	96. (11.)	96. (8.)	91. (11.)	90. (11.)	96. (8.)	77.* -
pH	8.1 (.3)	8.1 (.2)	8.4 (.3)	8.3 (.1)	8.4 (.2)	8.1 (.5)	8.3 (.1)	8.1 (.2)	7.5 (1.2)
Turbidity	3.83 (3.35)	4.26 (2.71)	3.39 (1.21)	2.84 (1.06)	2.69 (1.30)	3.60 (3.04)	3.16 (1.62)	5.33 (1.85)	8.42 (2.67)
Secchi Disk Depth	2.3 (0.5)	2.6 (1.0)	2.7 (0.4)	3.4 (1.4)	4.3 (0.9)	2.6 (0.9)	2.2 (0.6)	1.6 (0.3)	- -
Chlorophyll <u>a</u>	2.3 (0.8)	2.1 (0.9)	2.3 (0.9)	1.7 (0.8)	1.6 (0.6)	2.4 (0.9)	2.9 (1.0)	3.8 (0.7)	2.9* -
Temperature	5.7 (2.0)	8.6 (1.8)	12.1 (2.0)	18.0 (2.2)	21.3 (1.3)	18.8 (2.7)	12.9 (2.7)	9.2 (2.3)	4.5 (0.5)
Water Level	174.4 (0.3)	174.4 (0.2)	174.4 (0.2)	174.4 (0.2)	174.4 (0.2)	174.3 (0.1)	174.2 (0.1)	174.2 (0.2)	- -

*n = 1 All other December means are based on n = 2.

** Does not meet MOE Water Quality Objectives

() Standard error in parentheses

Table 5b: Ten-Year Averages by Station for Turbidity

	STATION NO.								
	112	501	518	648	810	994	(1041/1042) 1008	1016	1040
10-Yr. Mean	2.6	2.6	4.5	2.5	3.9	3.5	4.9	3.7	4.4
Std. Error	(2.2)	(2.2)	(4.2)	(1.8)	(3.0)	(2.3)	(3.6)	(3.2)	(4.1)

Table 6: Long-Term Changes in Selected Water Quality Parameters, Nanticoke, 1969-1978

Parameter	All Stations	Average Value Nearshore Stations (N) (0-2 km from shore)	Offshore Stations (O) (2 km + from shore)	Average Change in % of Average Value per Year									Significance Trend*					
				Mean			Min			Max			ALL	N	O	ALL	N	O
				ALL	N	O	ALL	N	O	ALL	N	O						
Conductivity umho/cm	309.5 \pm 1.2	309.9 \pm 1.2	308.7 \pm 1.1	-1.10	-1.10	-1.10	-1.28	-1.28	-1.28	-1.00	-1.00	-0.99	S	S	S	D	D	D
Total P mg/L P	0.017 \pm .001	0.018 \pm 0.001	0.015 \pm .007	-1.89	-0.70	-4.60	-3.80	-2.95	-6.20	0.00	1.55	-3.00	S	S	S	D	D	D
Total N mg/L N	0.405 \pm .015	0.416 \pm .015	0.385 \pm .015	1.95	2.30	1.40	0.66	1.00	0.05	3.25	3.59	2.78	S	S	S	I	I	I
pH SU	8.22 \pm 0.05	8.21 \pm 0.05	8.24 \pm 0.05	-0.00	0.00	0.00	-0.12	-0.19	-0.25	0.20	0.20	0.20	NS	NS	NS	-	-	-
Turbidity FTU	3.56 \pm 0.34	4.12 \pm 0.46	2.51 \pm 0.21	-4.35	-2.85	-11.5	-7.60	-6.70	-14.40	-1.06	1.00	-8.66	S	S	S	D	D	D
Phytoplankton crop ASU/mL	377.3 \pm 37.1	398.8 \pm 40.7	337.3 \pm 33.9	3.90	4.29	2.60	0.50	0.70	0.85	7.35	7.80	6.10	S	S	S	I	I	I
Kjeldahl N mg/L N	0.300 \pm 0.012	0.308 \pm 0.12	0.286 \pm 0.42	-0.56	-0.38	-1.20	-1.90	-1.70	-2.70	0.80	0.95	0.20	NS	NS	S	-	-	D
Chloride mg/L	22.7 \pm 0.2	22.7 \pm 0.3	22.7 \pm 0.2	-3.00	-3.00	-3.00	-3.40	-3.45	-3.38	-2.65	-2.60	-2.70	S	S	S	D	D	D
Diss. Oxygen % Sat'n	96.9 \pm 3.4	97.1 \pm 3.6	95.7 \pm 3.4	0.17	-0.10	0.38	-0.90	-1.27	-0.70	1.27	1.05	1.47	NS	NS	NS	-	-	-
Chlorophyll a ug/L	2.4 \pm 0.2	2.2 \pm 0.1	1.9 \pm 0.1	-6.72	0.01	-0.72	-10.12	-3.40	-4.20	-3.31	3.42	2.76	S	NS	S	D	-	D
Temperature $^{\circ}$ C	14.7 \pm 0.7	14.7 \pm 0.7	14.5 \pm 0.7	-1.42	1.21	-1.70	-2.98	-2.74	-3.36	-0.14	0.33	-0.05	S	S	S	D	D	D
Secchi disk depth m	2.8 \pm 0.1	2.2 \pm 0.1	3.9 \pm 0.2	-3.58	-2.54	-3.56	-5.92	-5.20	-6.16	-1.25	0.11	-0.96	S	S	S	D	D	D
Water Level m	174.3 \pm 0.0	174.3 \pm 0.0	174.3 \pm 0.0	0.01	0.01	0.01	0.00	0.00	0.00	0.02	0.02	0.02	NS	NS	NS	-	-	-
Filt.React.P **mg P/L	1969-1978 .005 \pm .000 1970-1978 .004 \pm .000	.005 \pm .000	.005 \pm .000	-9.30 -3.33	-7.50	-11.68	-12.90 -10.00	11.40	-14.90	-5.67 +3.61	-3.60	-8.46	S NS	S	S	D -	D	D
**NH ₃ mg L/N	1969-1978 .026 \pm .004 1971-1978 .017 \pm .004	.024 \pm .003	.023 \pm .003	-17.16 -5.88	-14.76	-16.16	-22.70 -12.50	-18.87	-20.40	-11.59 0.00	-10.60	-11.90	S S	S	S	D D	D	D
**NO ₂ +NO ₃ mg L/N	1969-1978 .106 \pm .010 1969-1972 .068 \pm .032 1973-1978 .137 \pm .036	110 \pm .010	.100 \pm .010	10.40 +3.68 +1.22	10.50	10.40	7.57 -21.32 -7.08	7.67	7.30	13.20 +29.41 +9.49	13.36	13.50	S NS NS	S	S	I - -	I	I

* S: significant change

D: decreasing trend

NS: no significant change

I: increasing trend

** See text for explanation of this data separation.

Table 7: Location of the 1978 CCIW Stations Used in Discriminant Analysis

Permanent Station Number	Latitude N	Longitude W
27	42-40-00	80-00-12
28	42-42-36	80-01-24
29	42-43-03	80-07-03
30	42-41-03	80-13-57
31	42-46-30	80-06-06

Table 8: Comparison of MOE and CCIW Values for Selected Water Quality Parameters
All concentrations in ug/L

Parameter	CCIW			MOE		
	\bar{X}	s	n	\bar{X}	s	n
Total phosphorus (as P) 1970 ¹	15	3	7 ¹	19	2	8*
1978	12	3	5	14	3	9
Filtered reactive phosphorus (as P)	5.7	4.0	7	5	1	8
	1.0	0.4	5	3	1	9
Nitrate + Nitrite (as N)	59.6	62.2	7	60	10	8
	119.2	37.2	5	170	10	9*
Ammonia (as N)	26	33	7	20	0	8
	2	1	5	10	0	9*

¹ Upper value - 1970; lower - 1978, except for NH₃ determined by MOE for which the upper value represents 1971.

* Indicates significant difference between CCIW and MOE means exists for this year.

Table 9: Comparison of MOE and CCIW Trace Metal Concentrations

(All measurements in ug/L)

Parameter	CCIW ¹		MOE ²			
	Stn.19	Stn.39	1978	1972-1977	Detection Limits	Precision
Cu(ug/L)	11(2-16)	12(8-17)	10+60	20-40	50	20
Fe	121(27-310)	35(13-111)	80+69	120-210	40	20
Mu	-	2(5-60)	-	-	40	10
Pb	3(2-4)	4(1-8)	30+50	10-90	40	20
Ni	4(1-5)	2	2+4	20-40	70	30
Li	2	-	-	-	20	60
Zn	10(5-14)	6(5-7)	10	20-50	50	20
Cr	d.l.	d.l.	20+60	20	20	10
Co	d.l.	d.l.	-	-	70	20
Cd	1	d.l.	-	0-20	20	10
Li	2	1	-	-	20	60
Hg	-	-	-	0.01-0.35	-	-

¹ Stn.19 is located off Grand River. Stn.39 is off the tip of Long Point at approximately 42° 30'N, 79°50'W. Samples were taken at 1 m. The numbers are the averages for the 8 cruises, and in brackets, the minimum and maximum values. "d.l." signifies that the concentrations were below the detection limits. The CCIW detection limits are about 1/10th of those given in this table for the Ministry of the Environment.

² The values give the range of concentrations in ug/L, except for the 1978 values, which represent the mean \pm 1 standard deviation. Because of the 20-fold preconcentration started in 1978, the detection limits and precision are, in effect, divided by this factor for 1978.

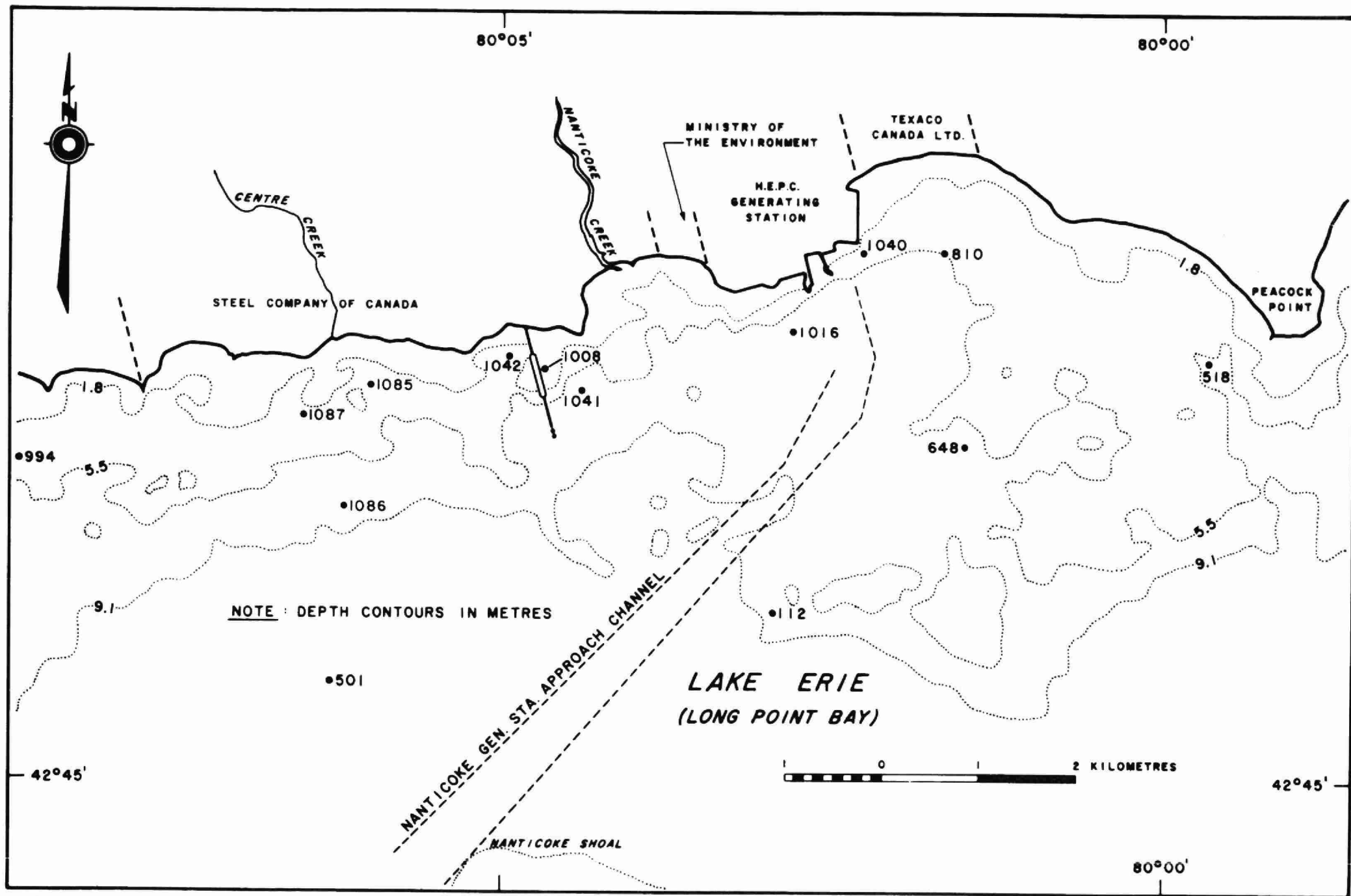


FIGURE 1a - NANTICOKE SAMPLING STATIONS (M.O.E.)

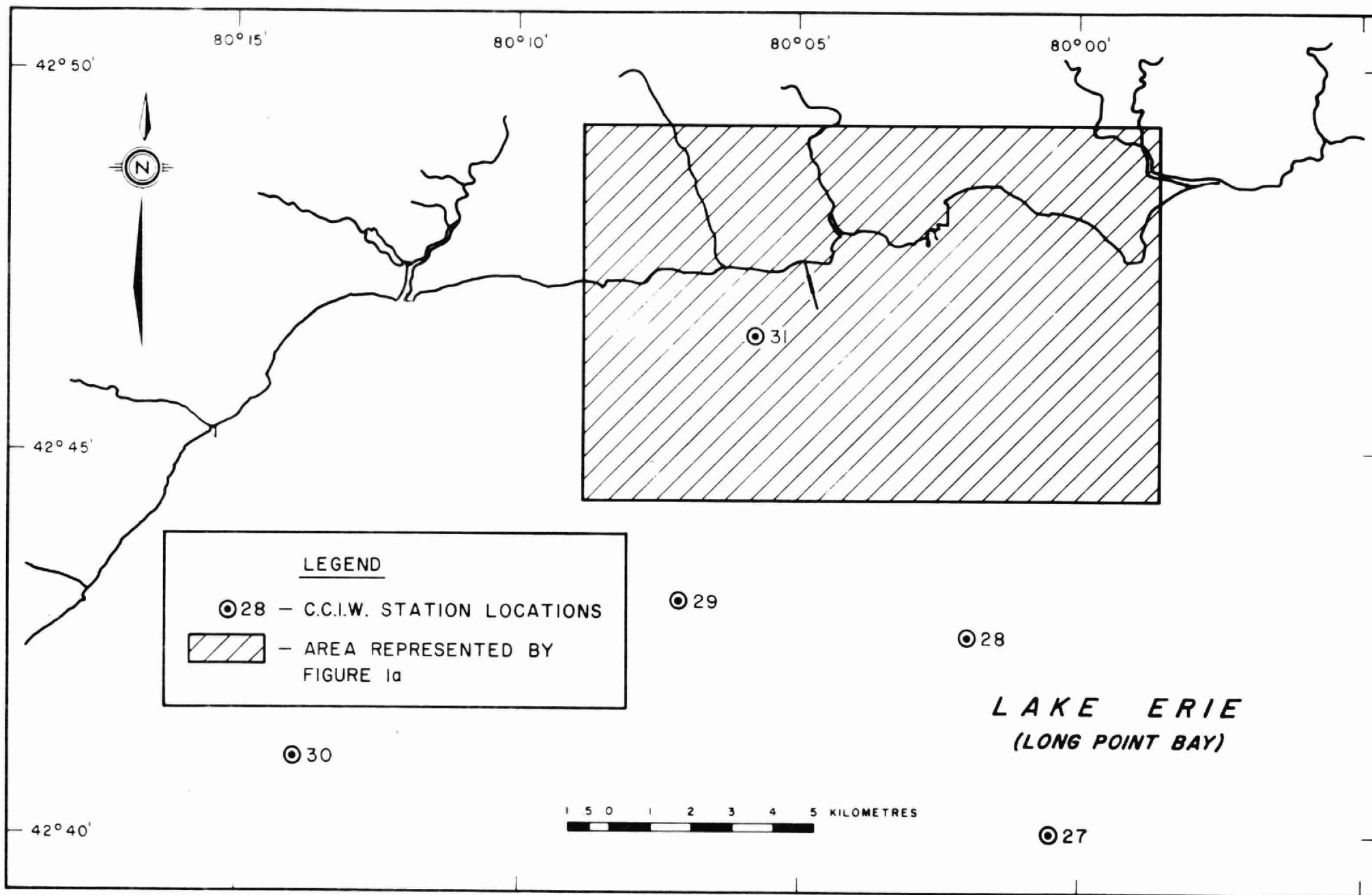


FIGURE 1b - M.O.E. NANTICOKE STUDY AREA AND C.C.I.W. PERMANENT STATION LOCATIONS FOR 1978.

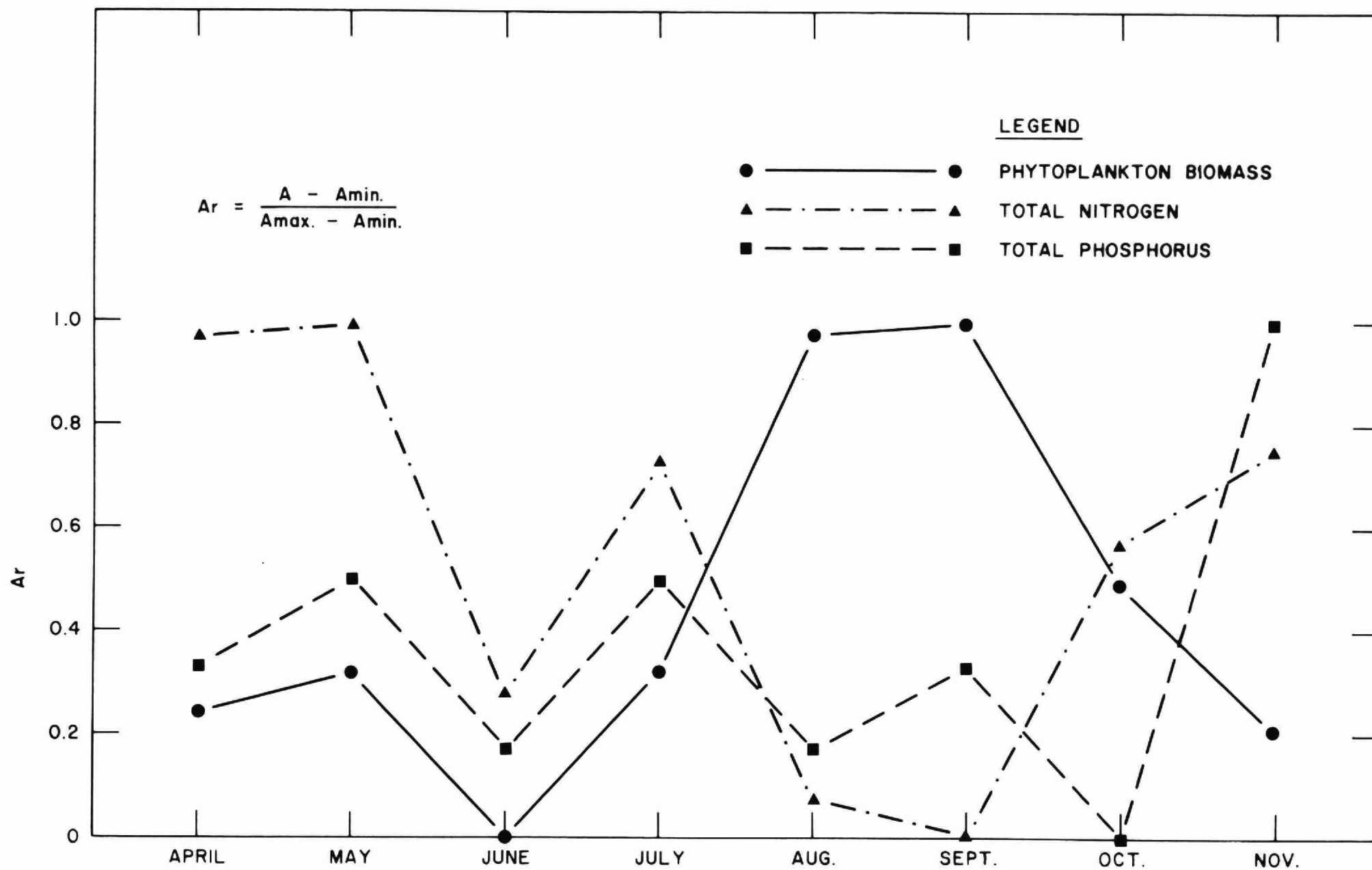


FIGURE 2a - NANTICOKE-LAKE ERIE SEASONAL VARIATION-AVERAGES 1969-1978.

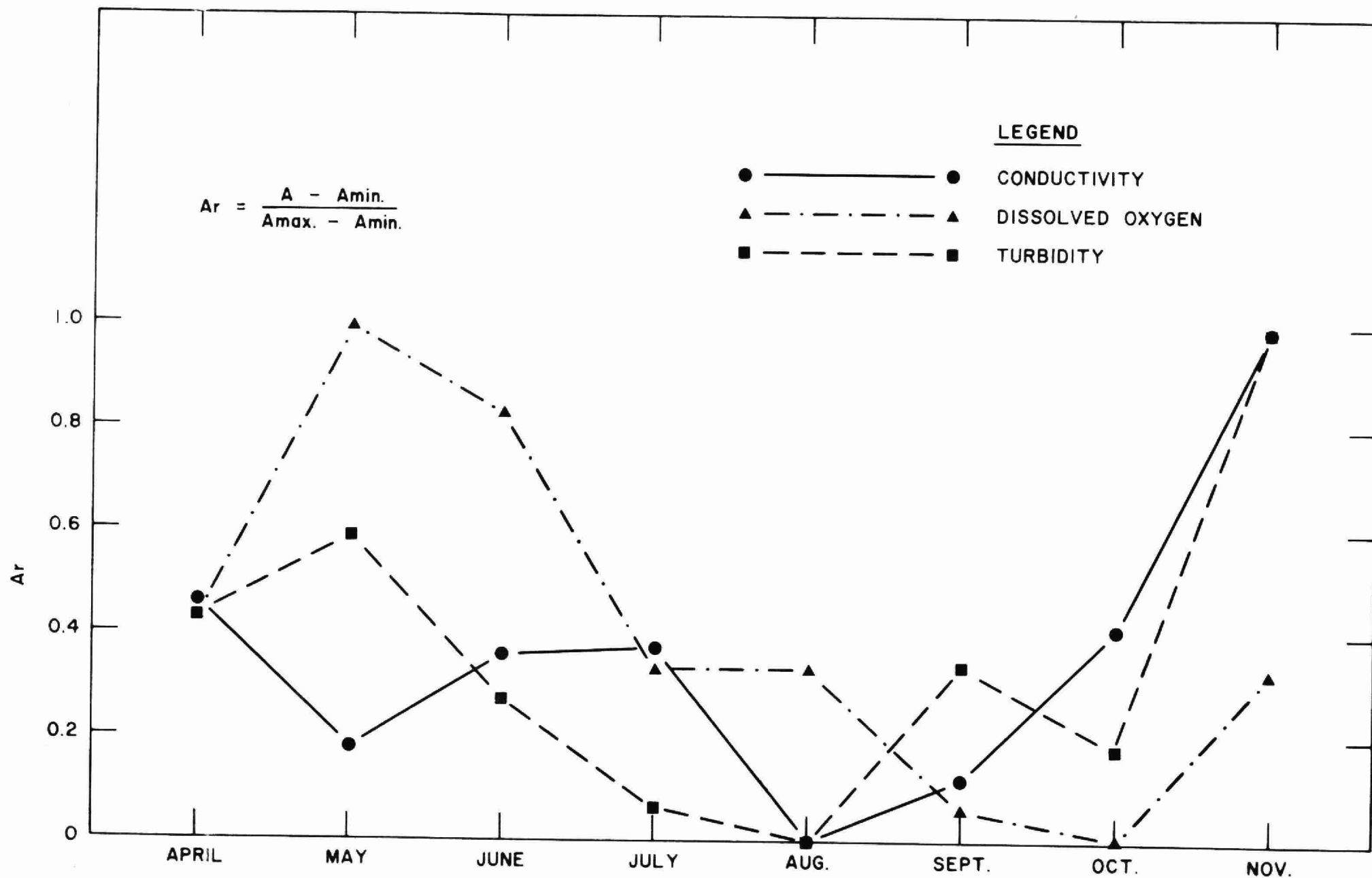
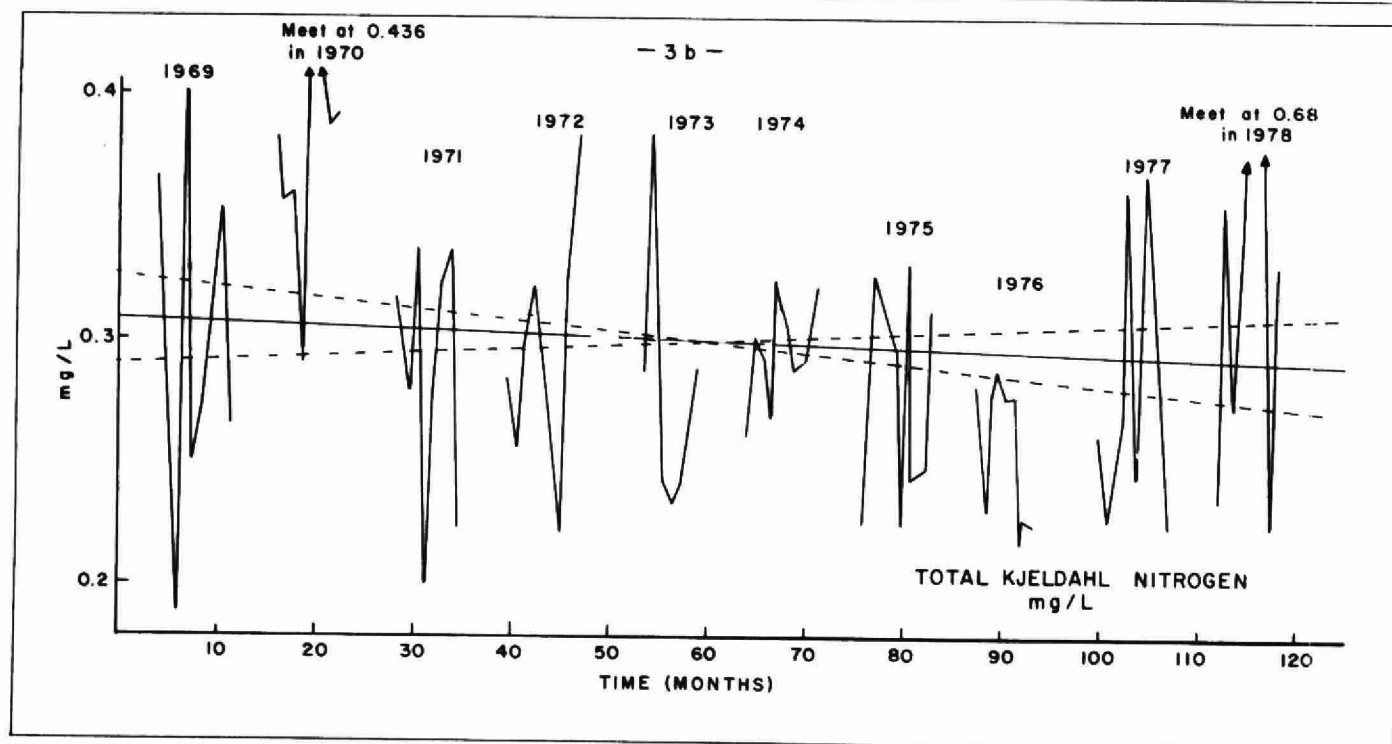
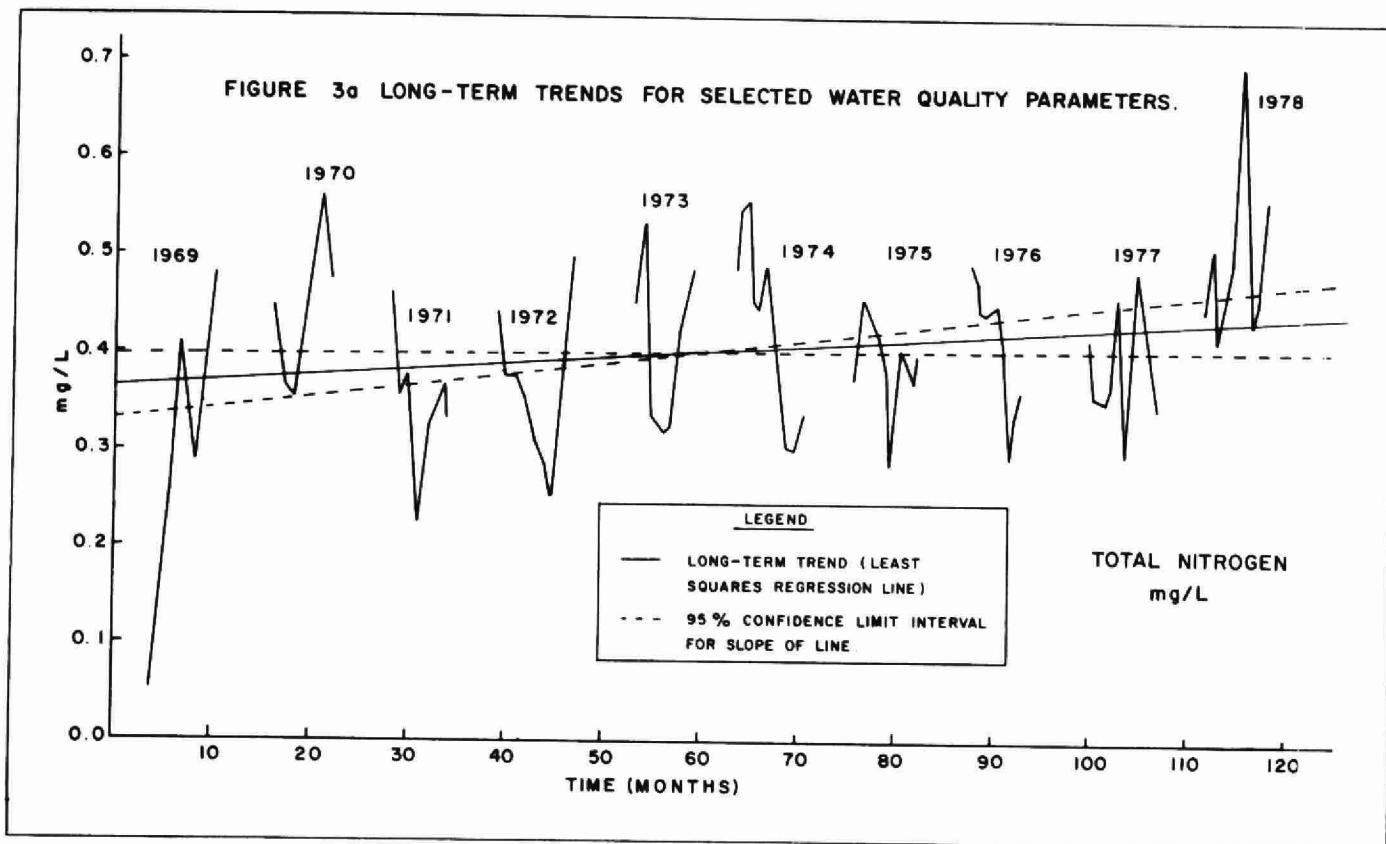
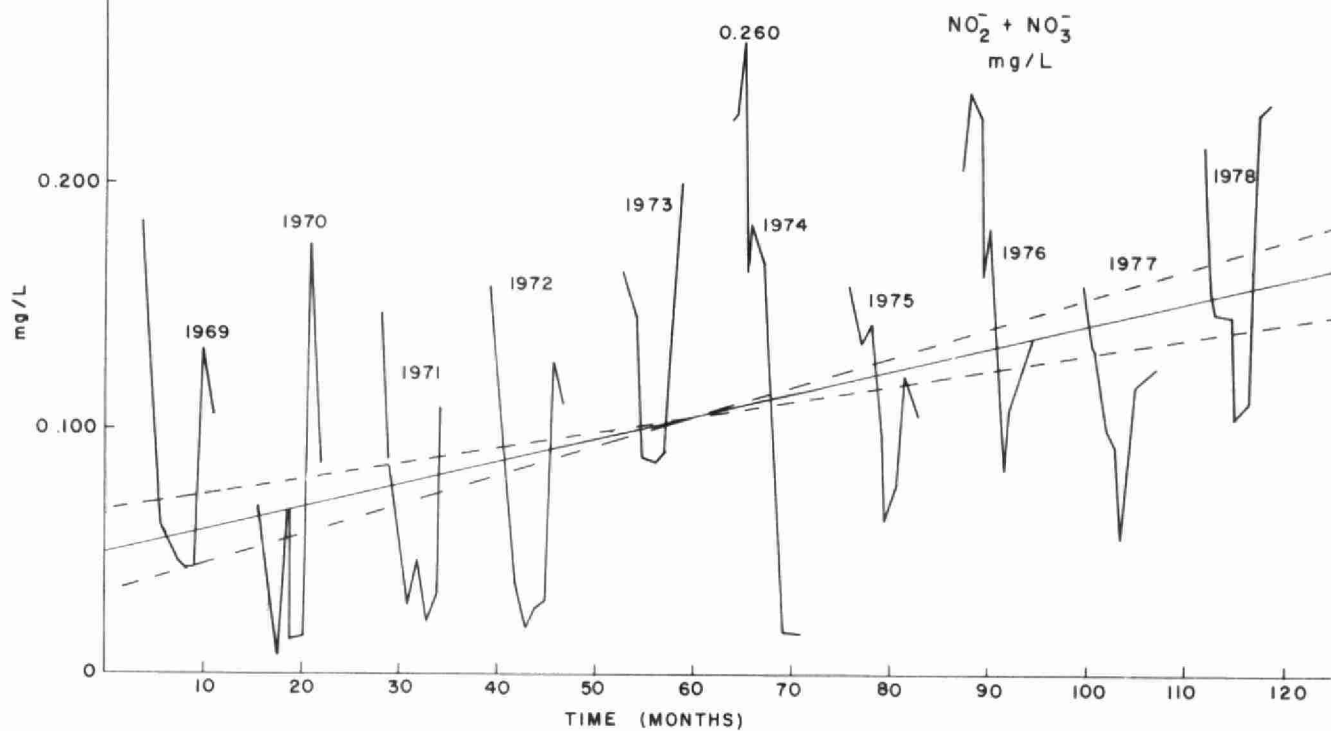


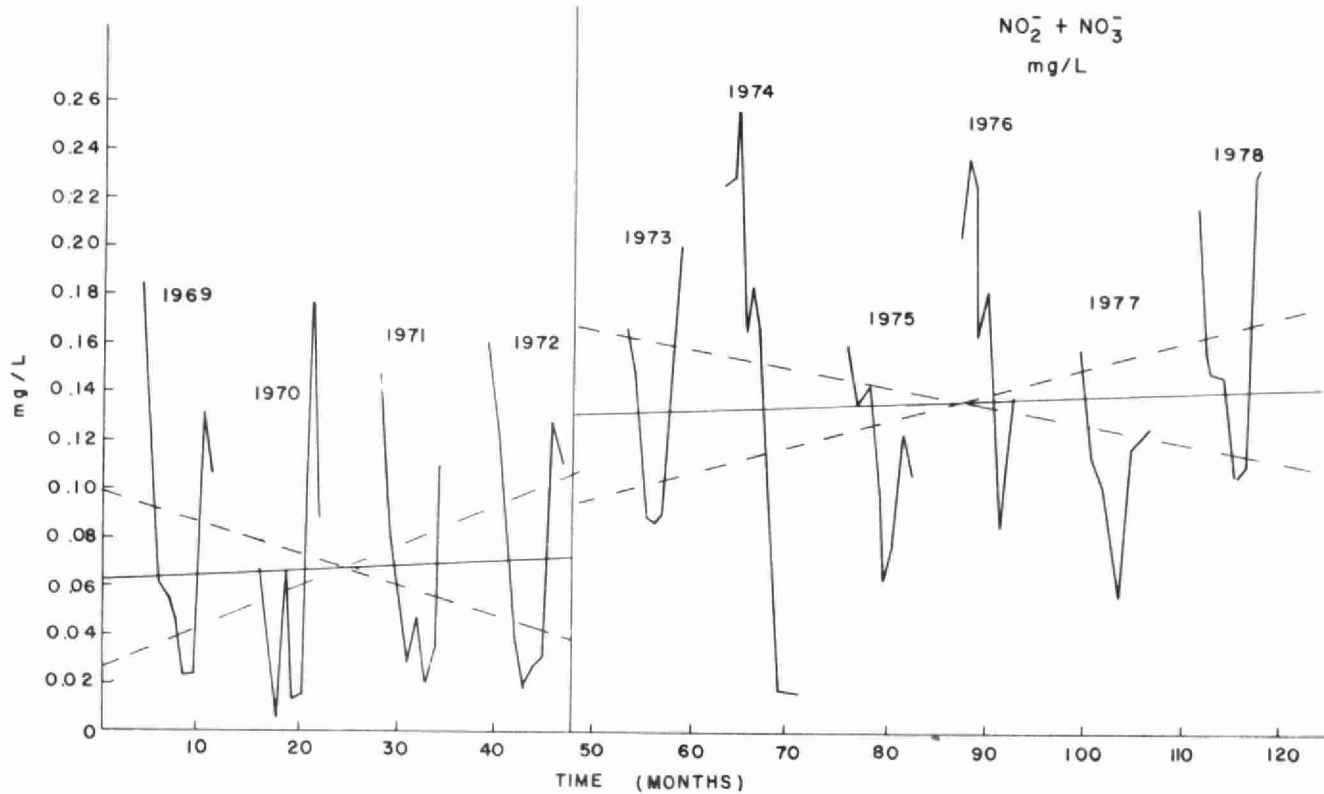
FIGURE 2b - NANTICOKE-LAKE ERIE SEASONAL VARIATION-AVERAGES 1969-1978.

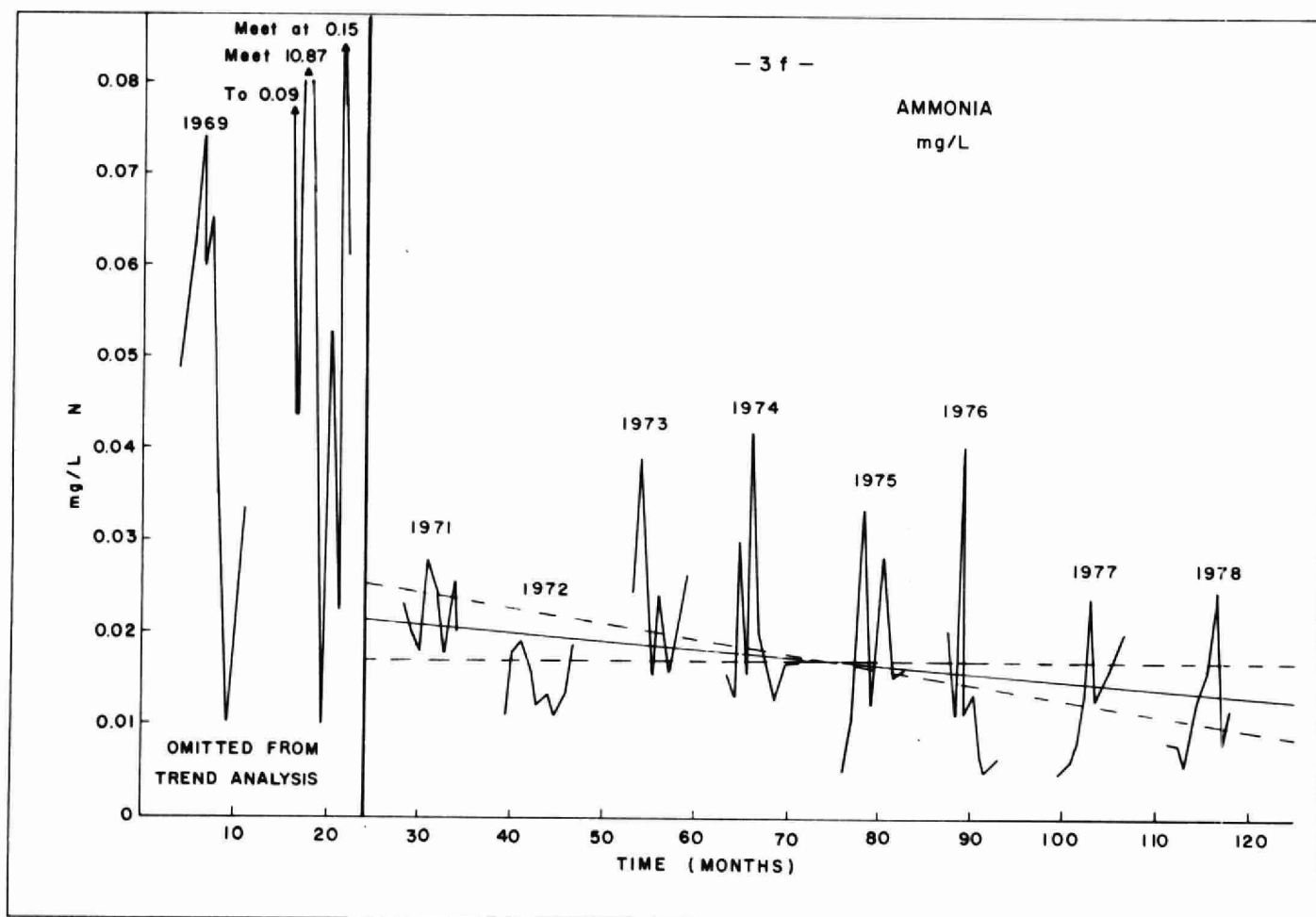
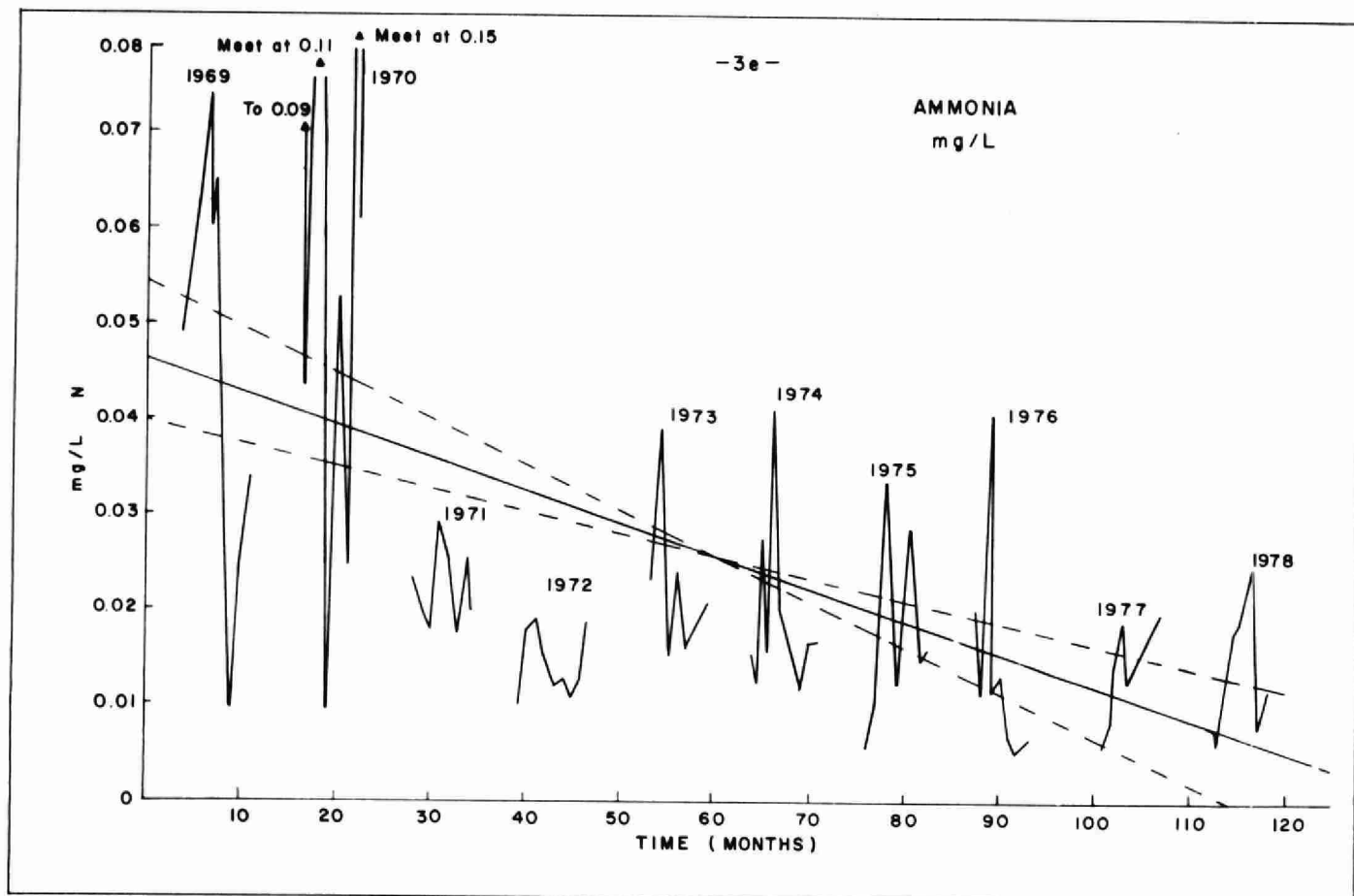


- 3 c -



- 3 d -

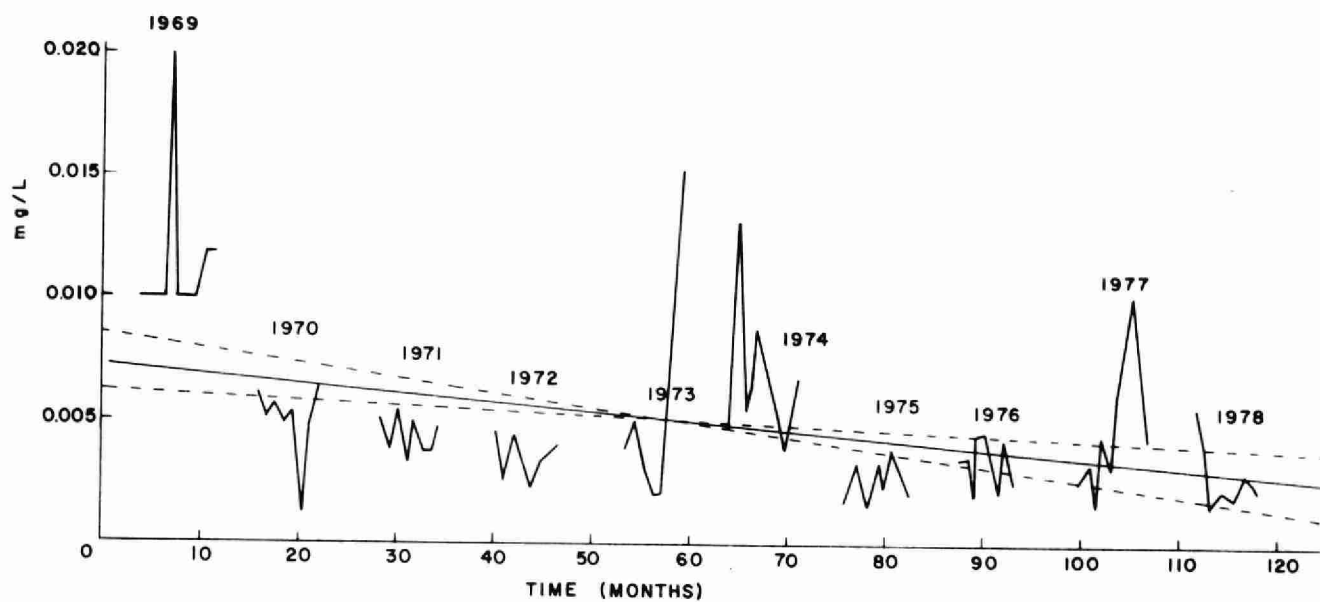




- 3 g -

FILTERED REACTIVE PHOSPHORUS

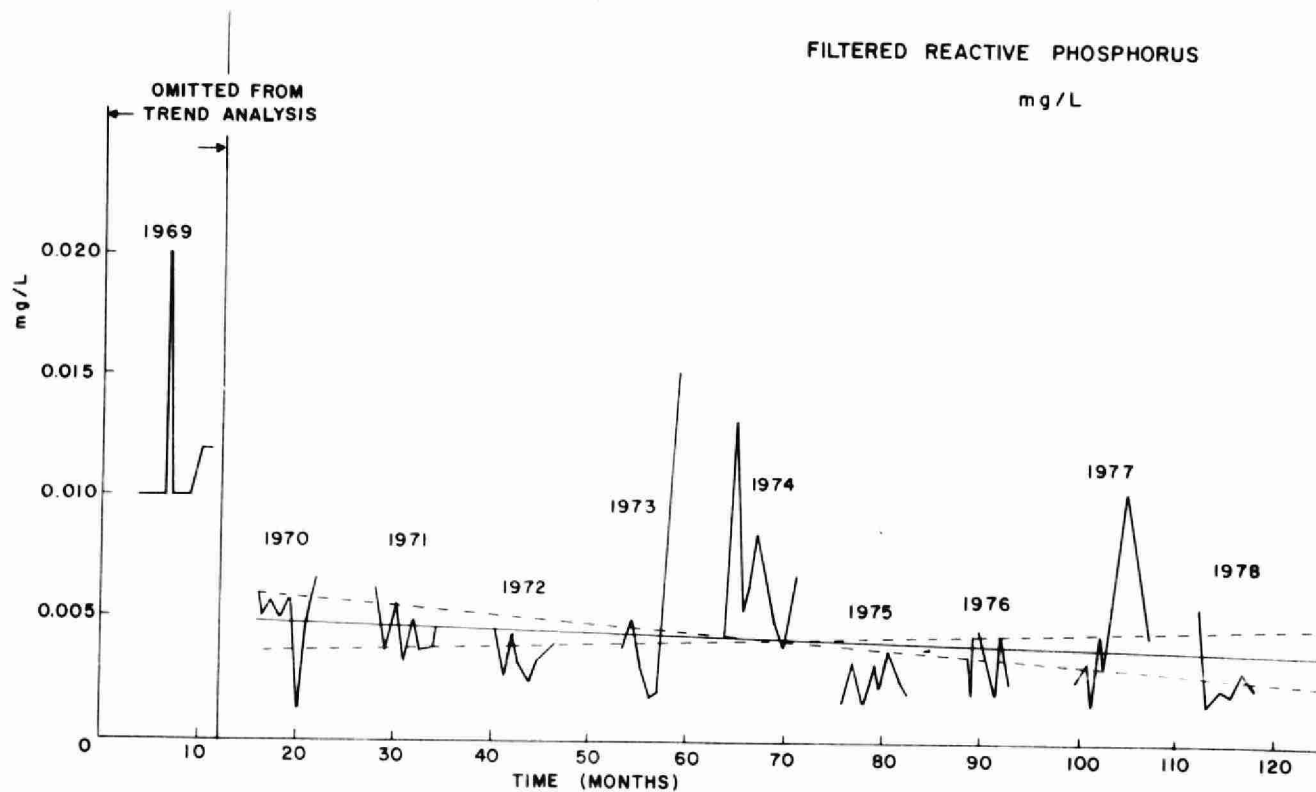
mg/L

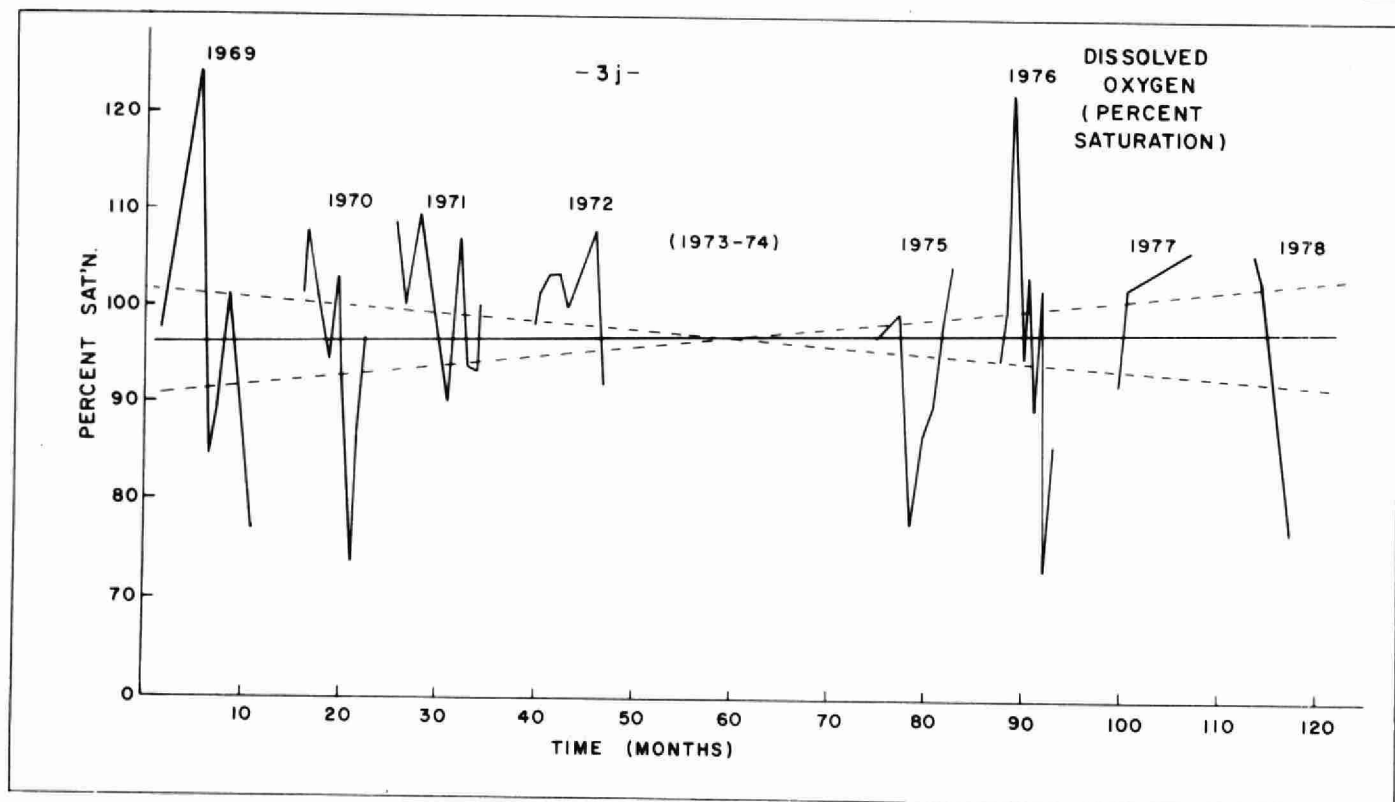
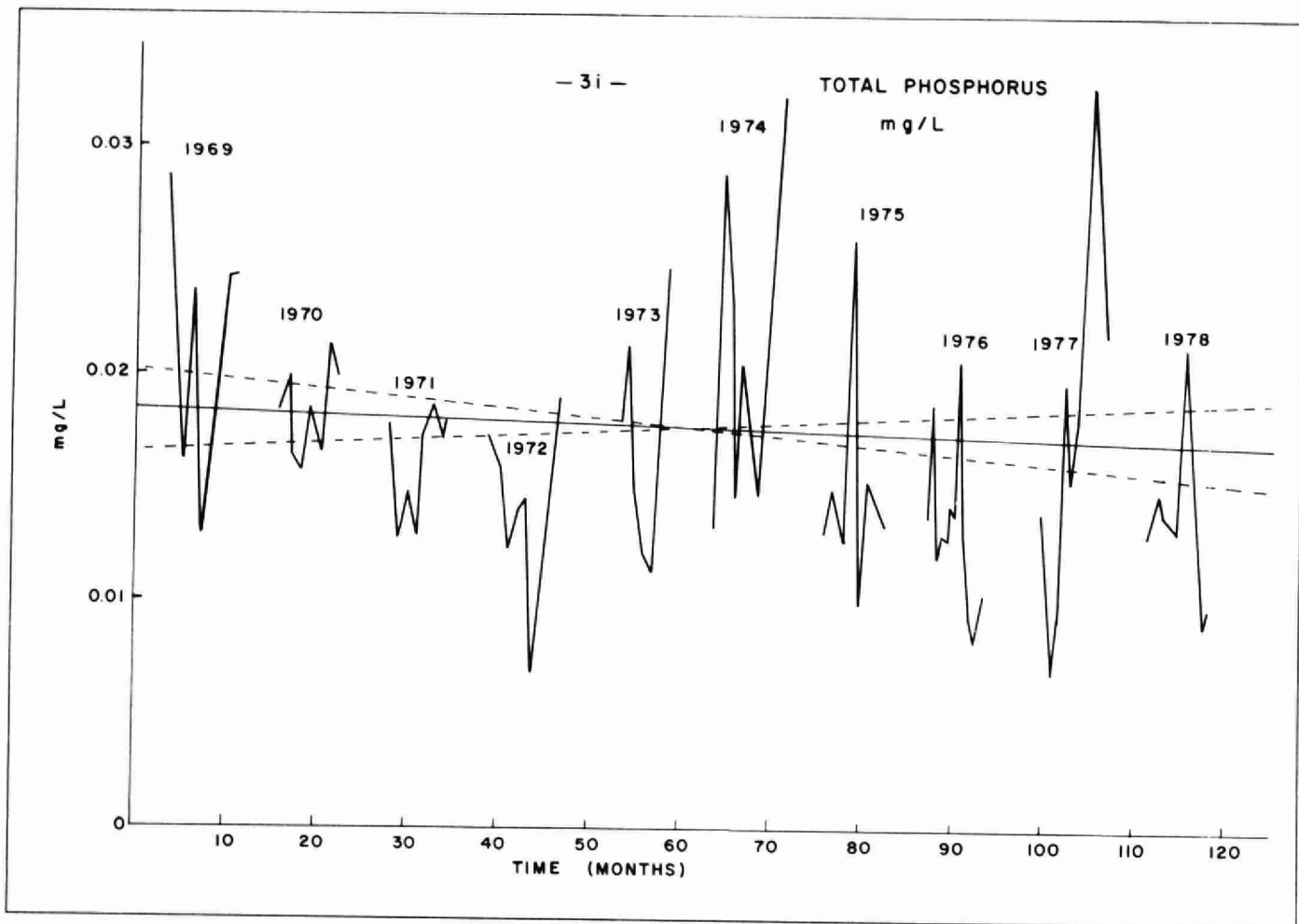


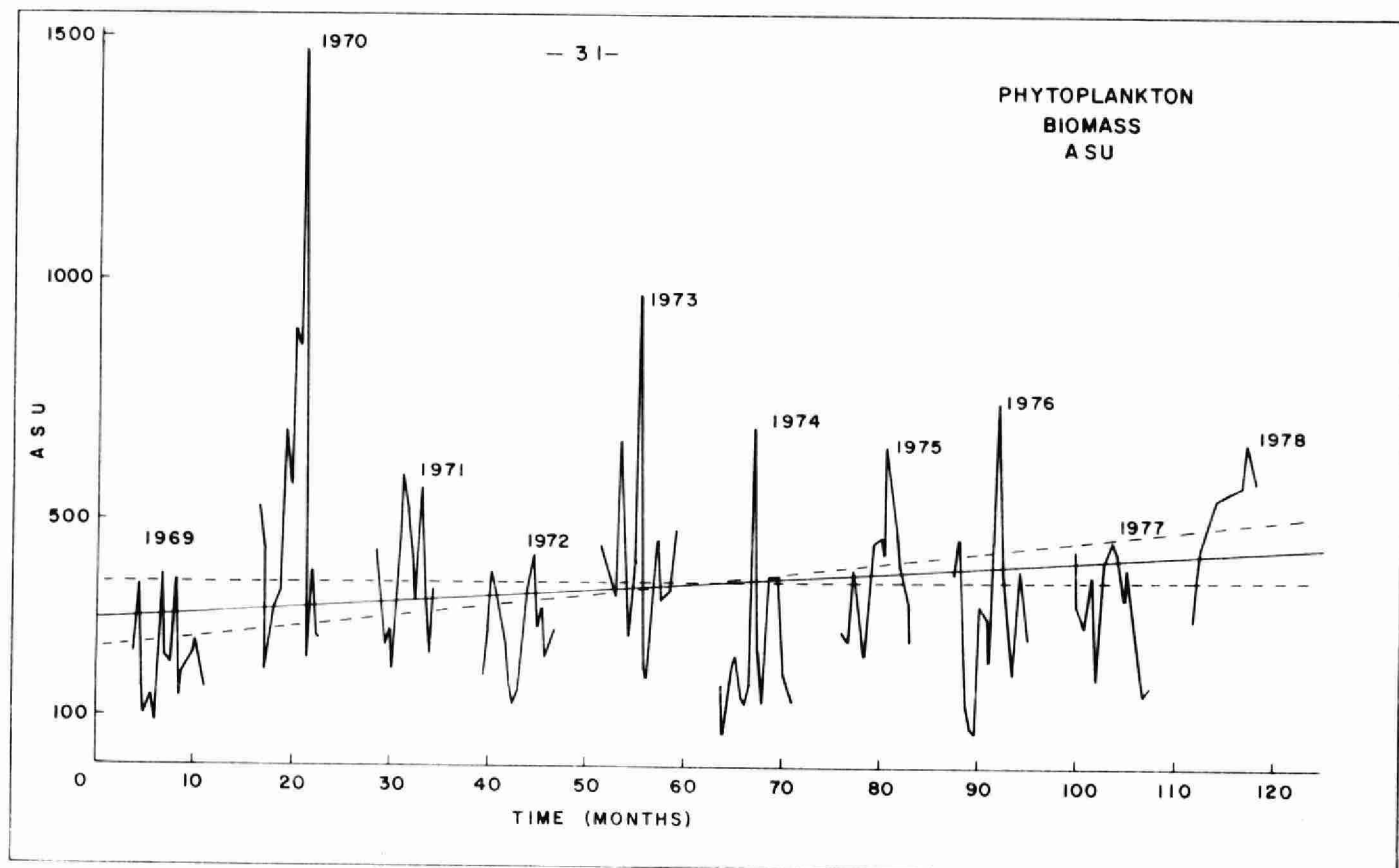
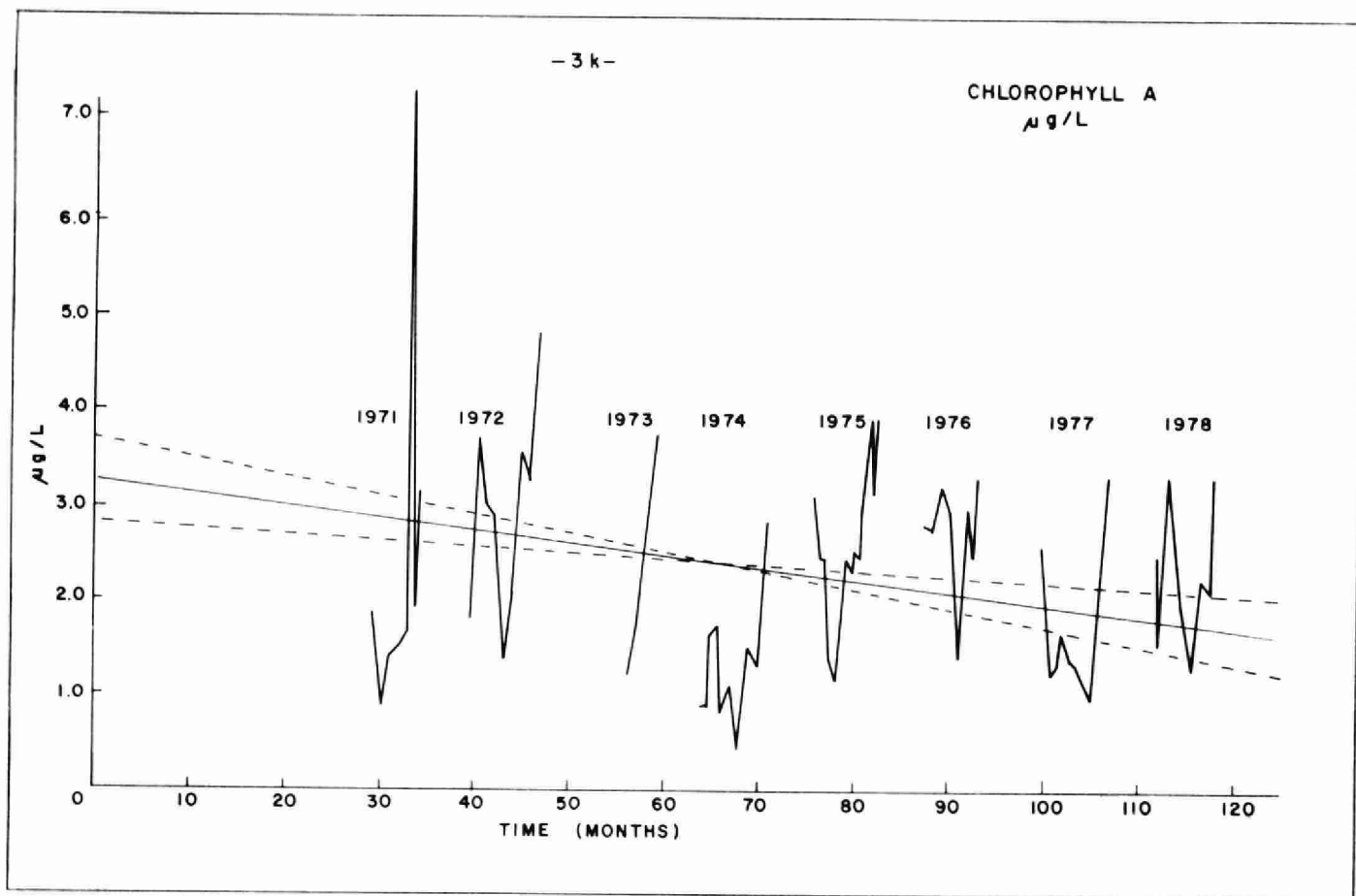
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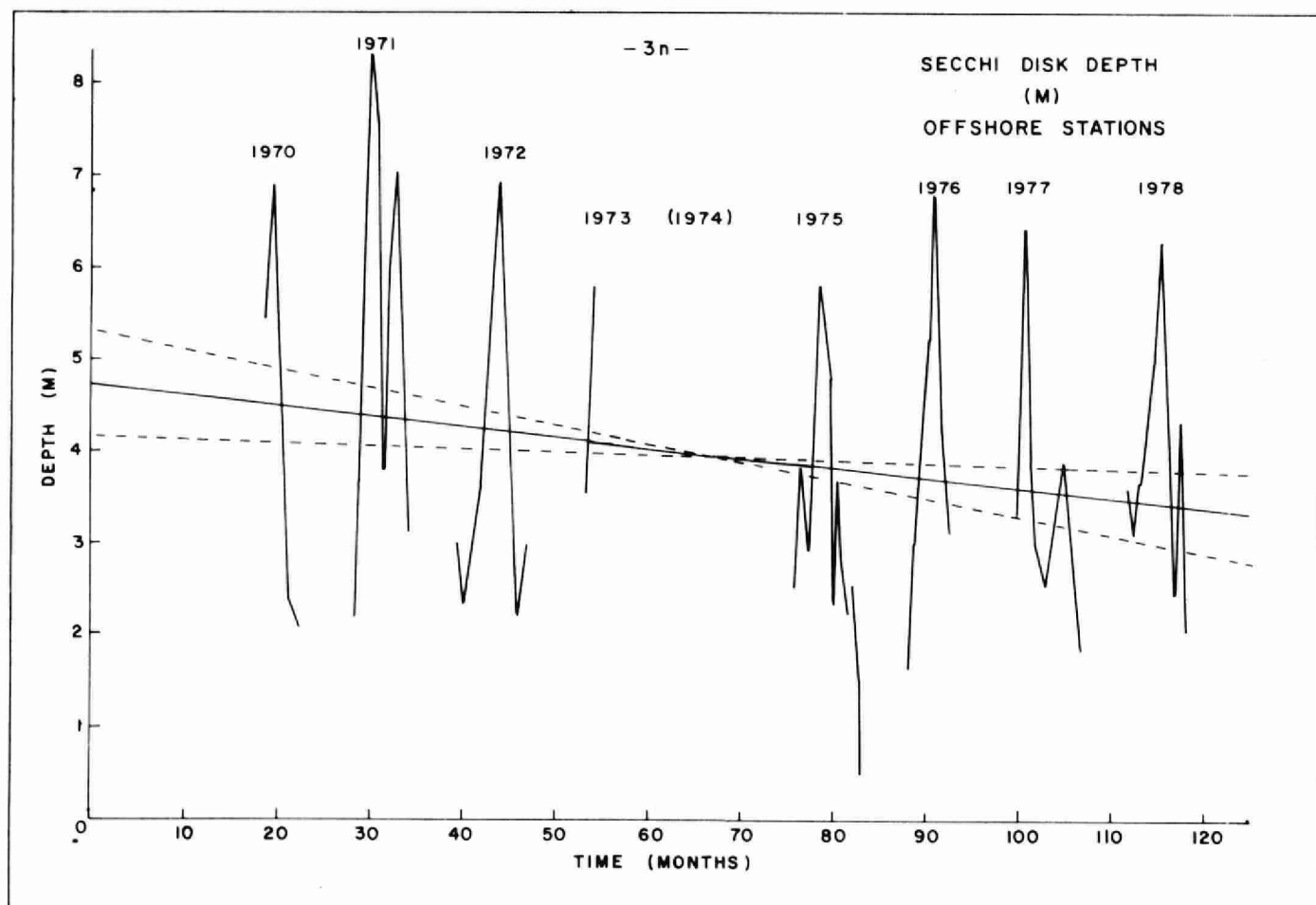
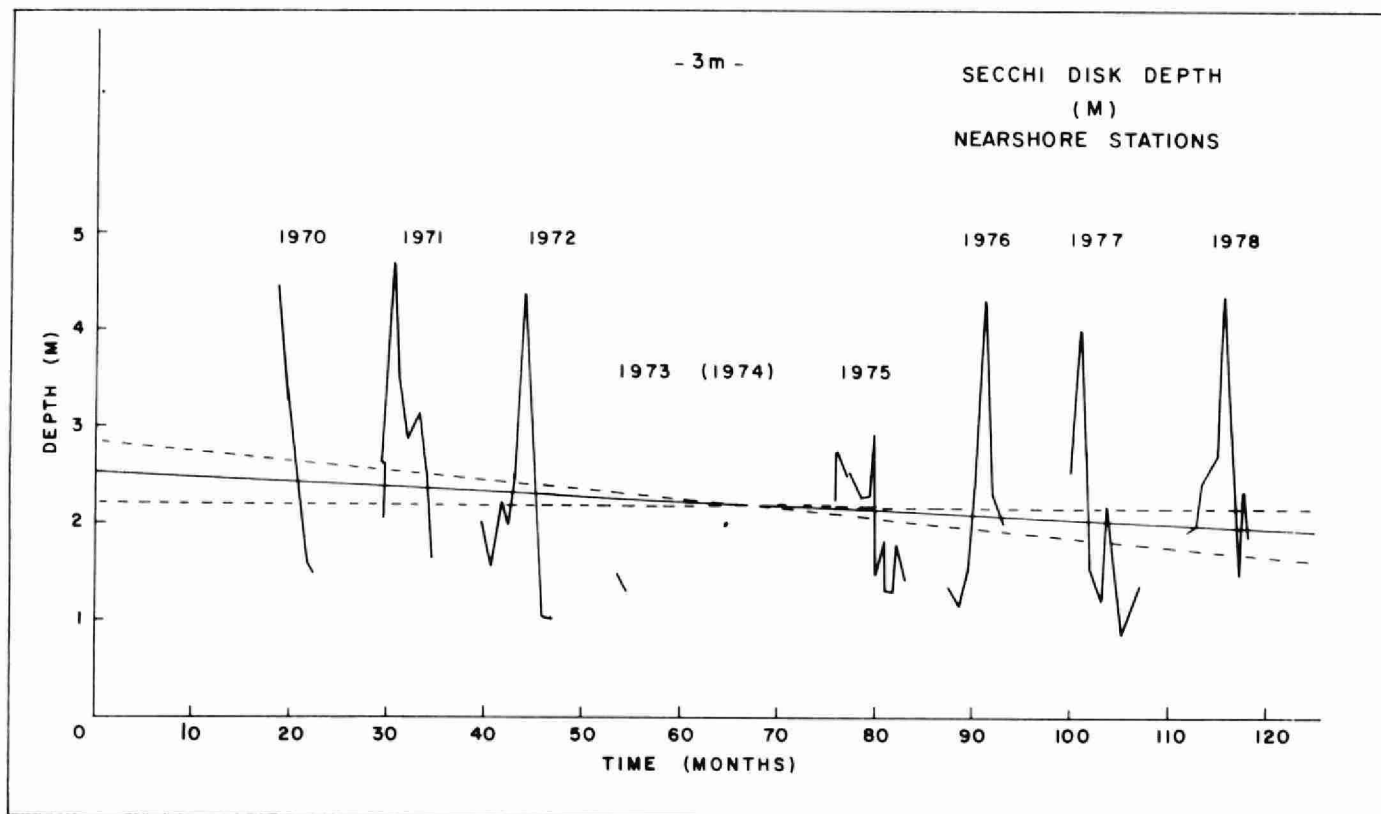
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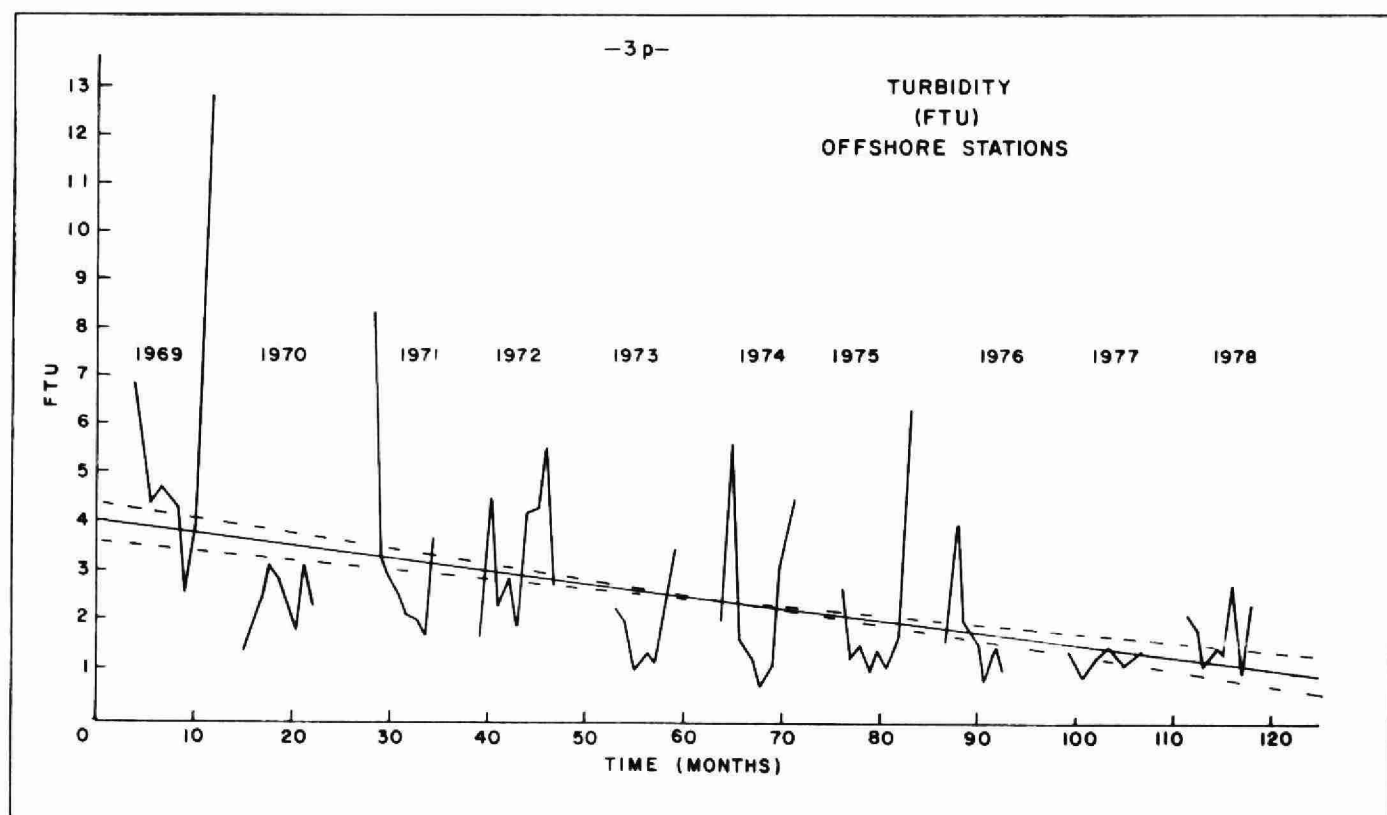
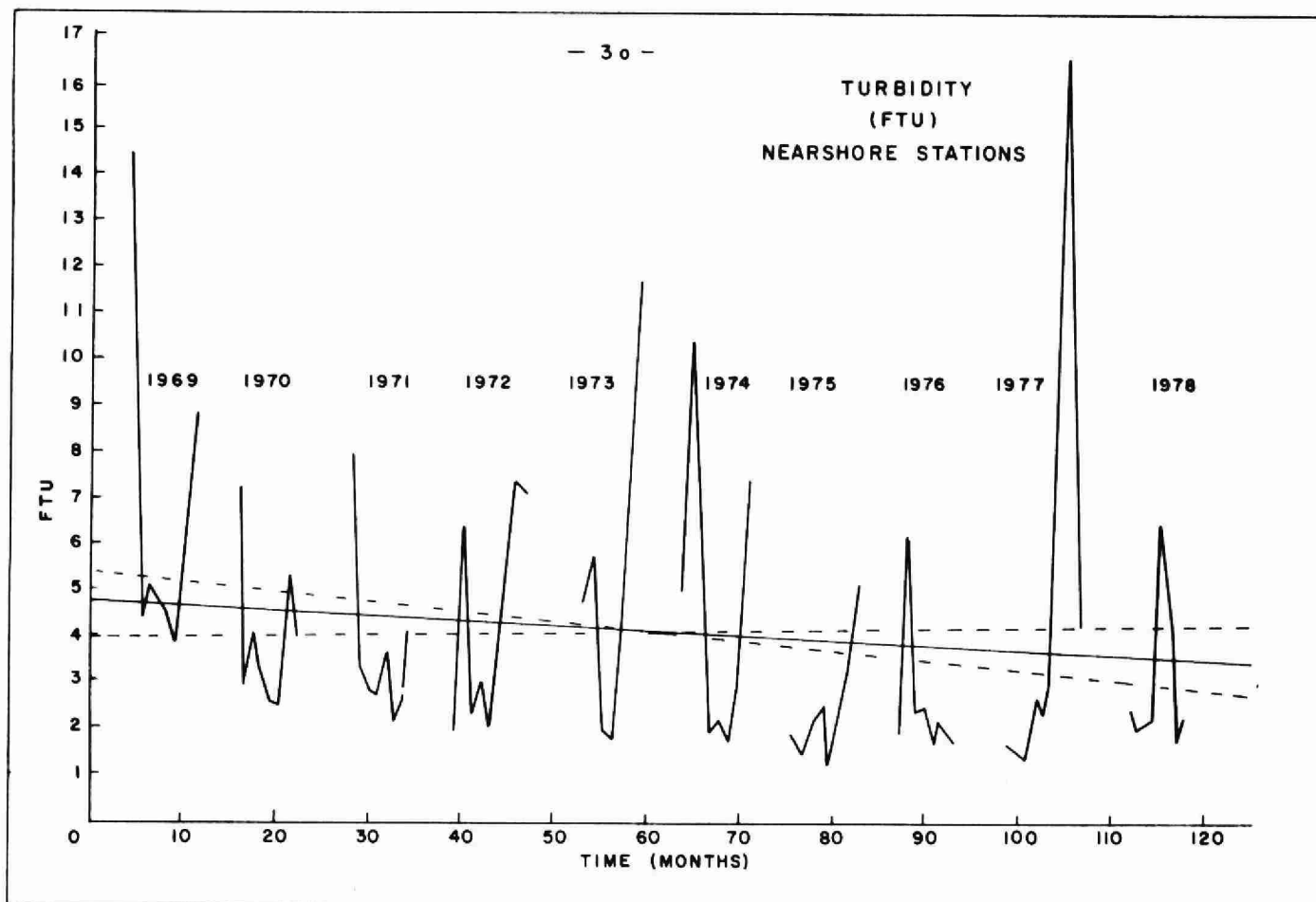
mg/L

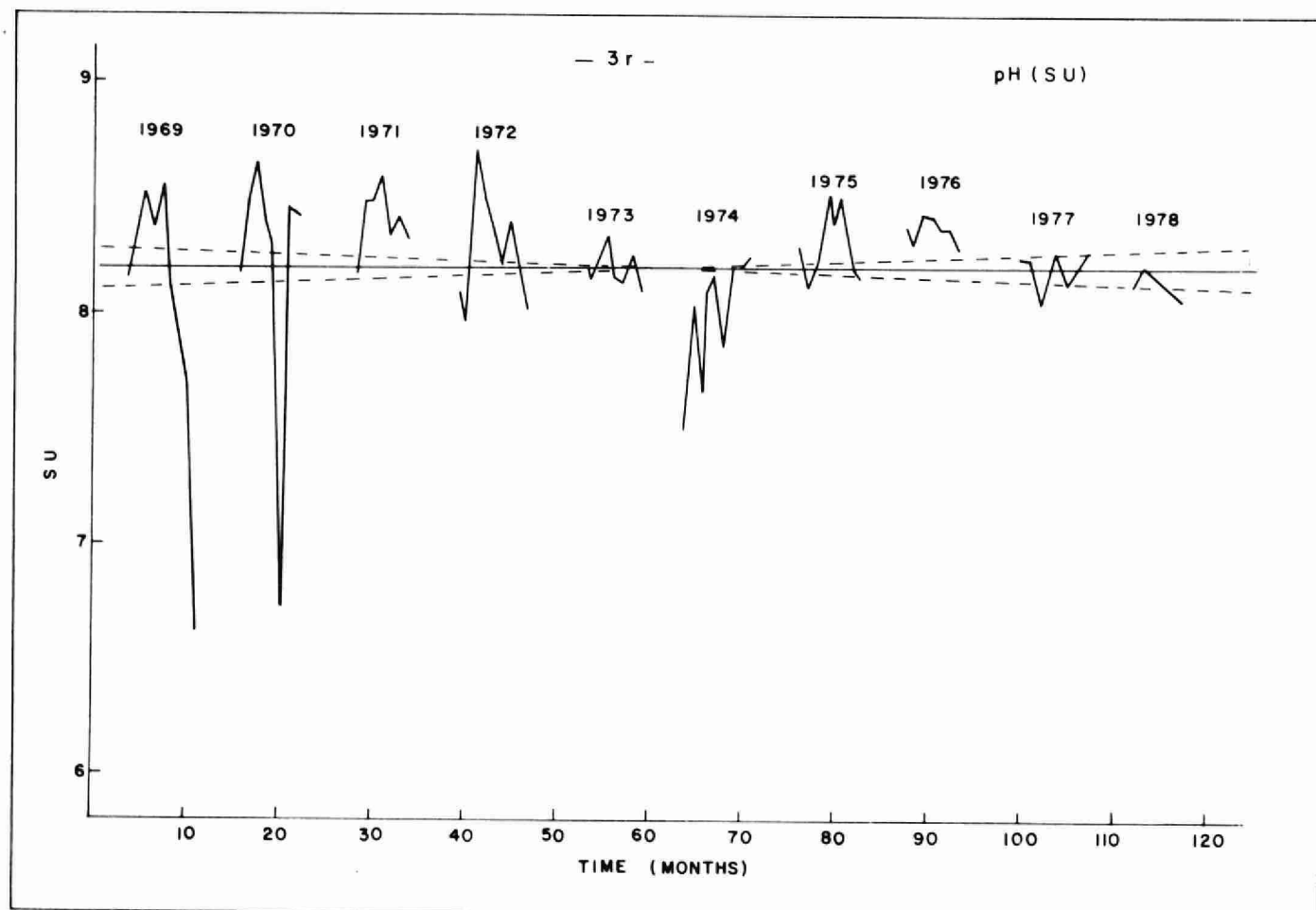
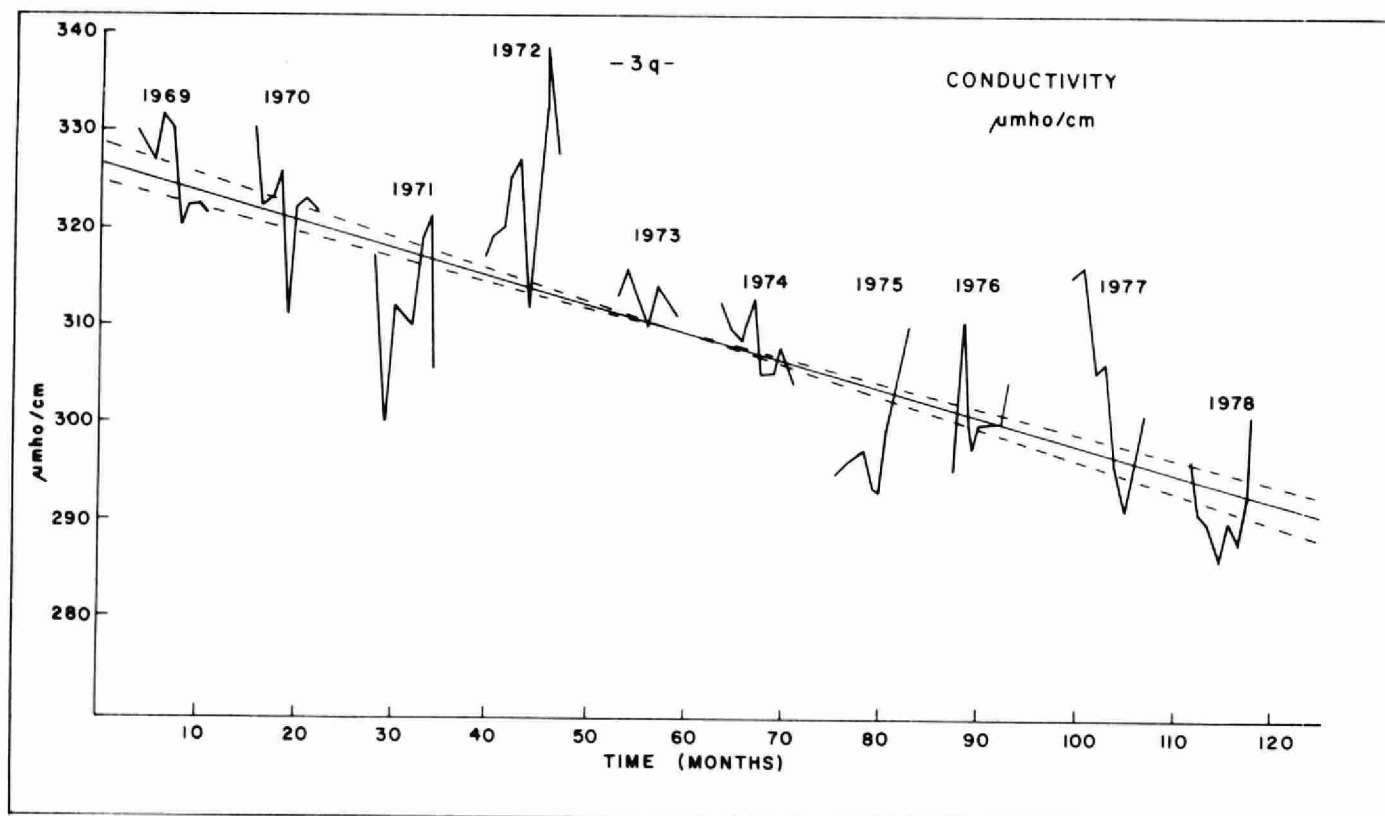












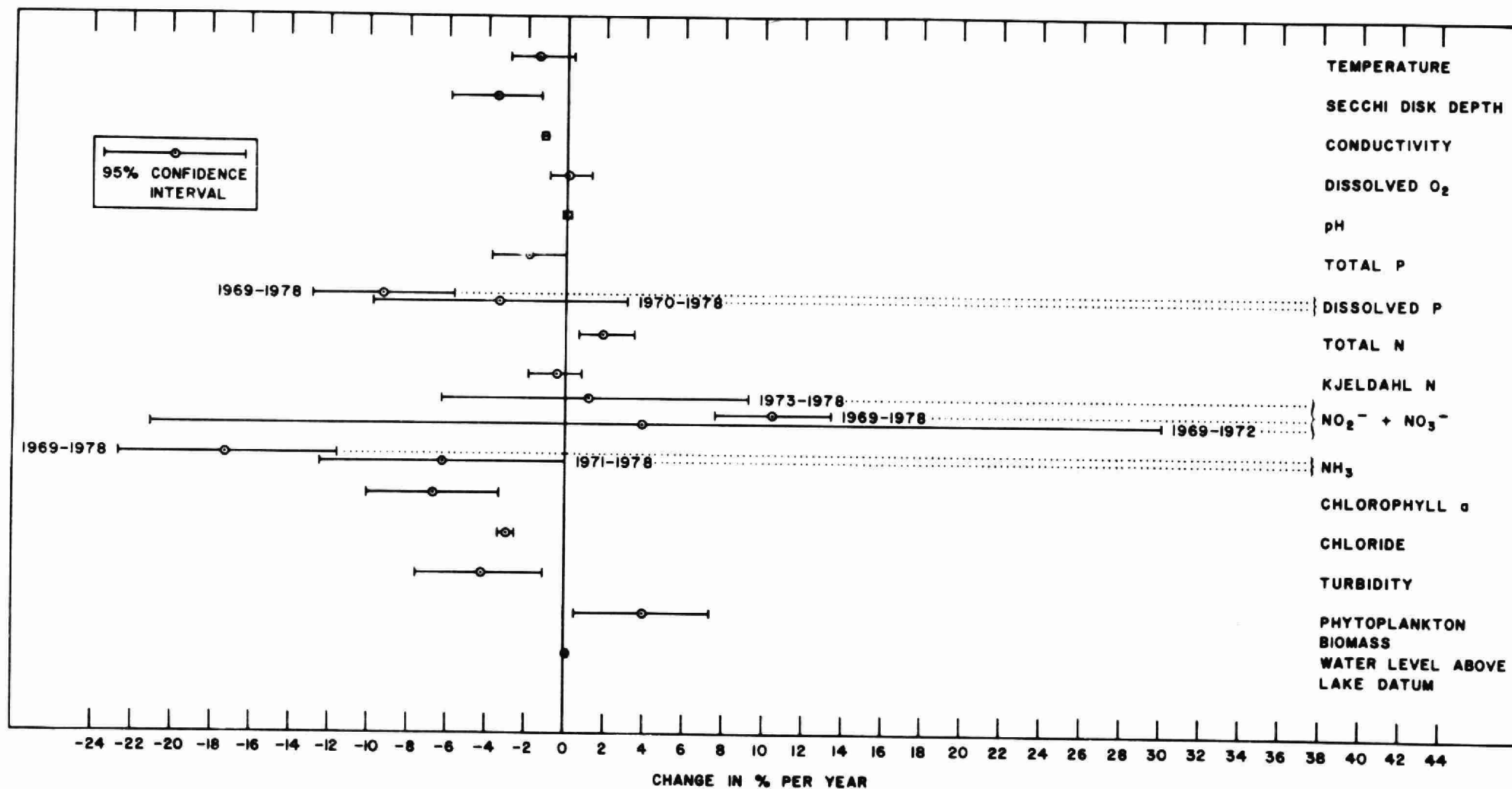


FIGURE 4 - NANTICOKE-LAKE ERIE LONG-TERM CHANGES, 1969-1978, ALL STATIONS.

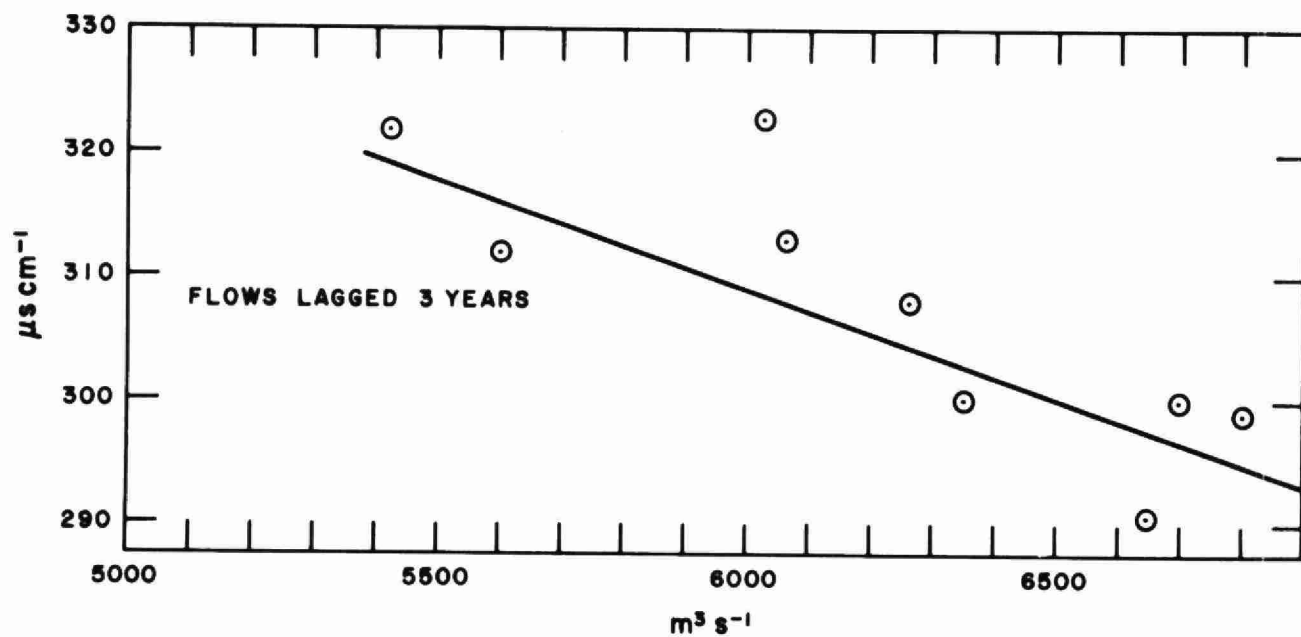


FIGURE 5a - CONDUCTIVITY AT NANTICOKE VS DETROIT RIVER FLOW.

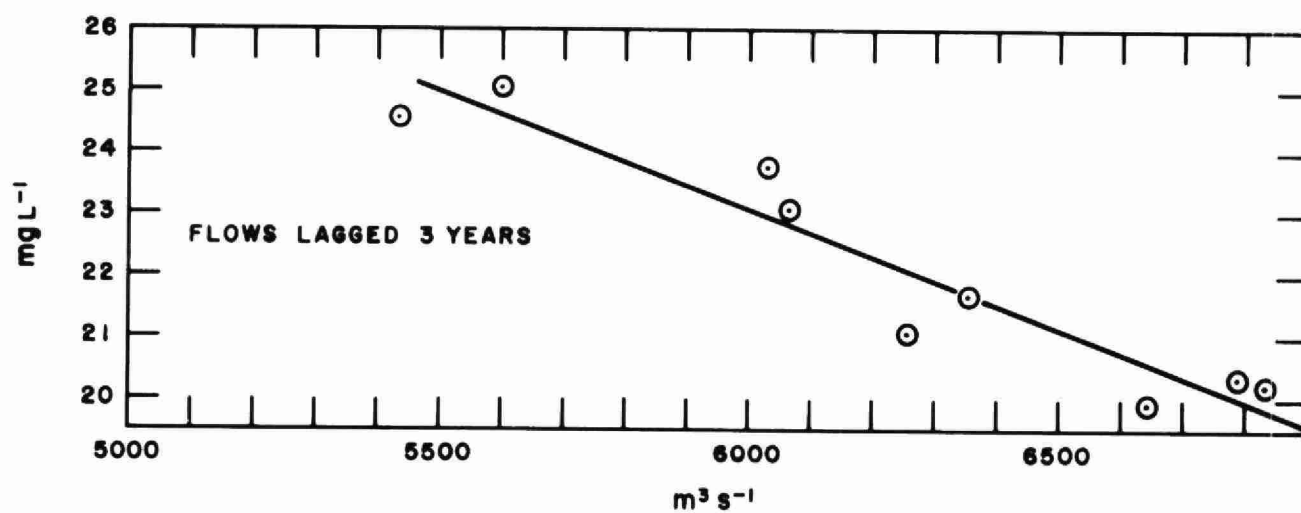
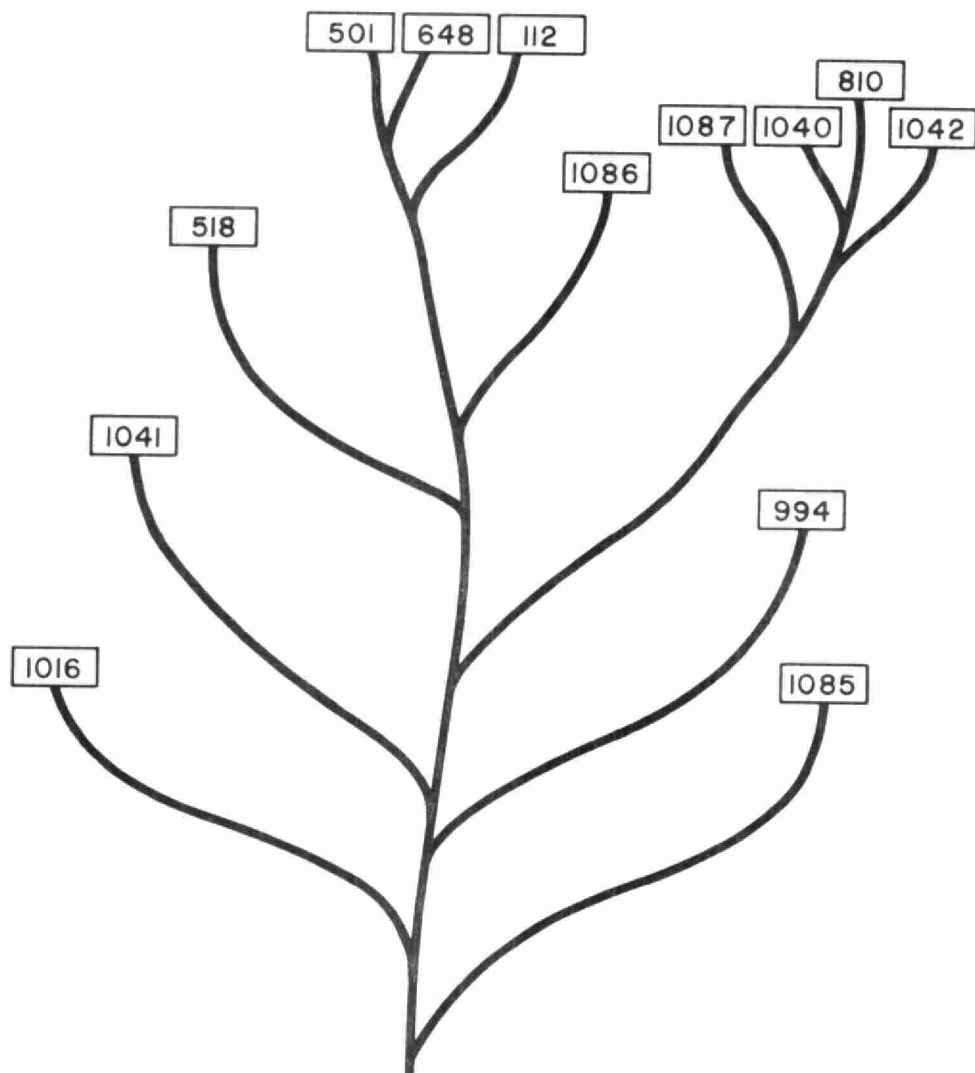


FIGURE 5b - DETROIT RIVER FLOW AND CHLORIDE CONCENTRATION AT NANTICOKE.



NOTE

DISTANCE BETWEEN BRANCHING
POINTS IS REPRESENTATIVE OF
STATISTICAL DISTANCE
(DIFFERENCE).

FIGURE 6 - DENDROGRAM SHOWING RELATIONSHIPS
BETWEEN STATIONS AT NANTICOKE, LAKE
ERIE (BASED ON CLUSTER ANALYSIS OF
EUCLIDEAN DISTANCES BETWEEN STATIONS).

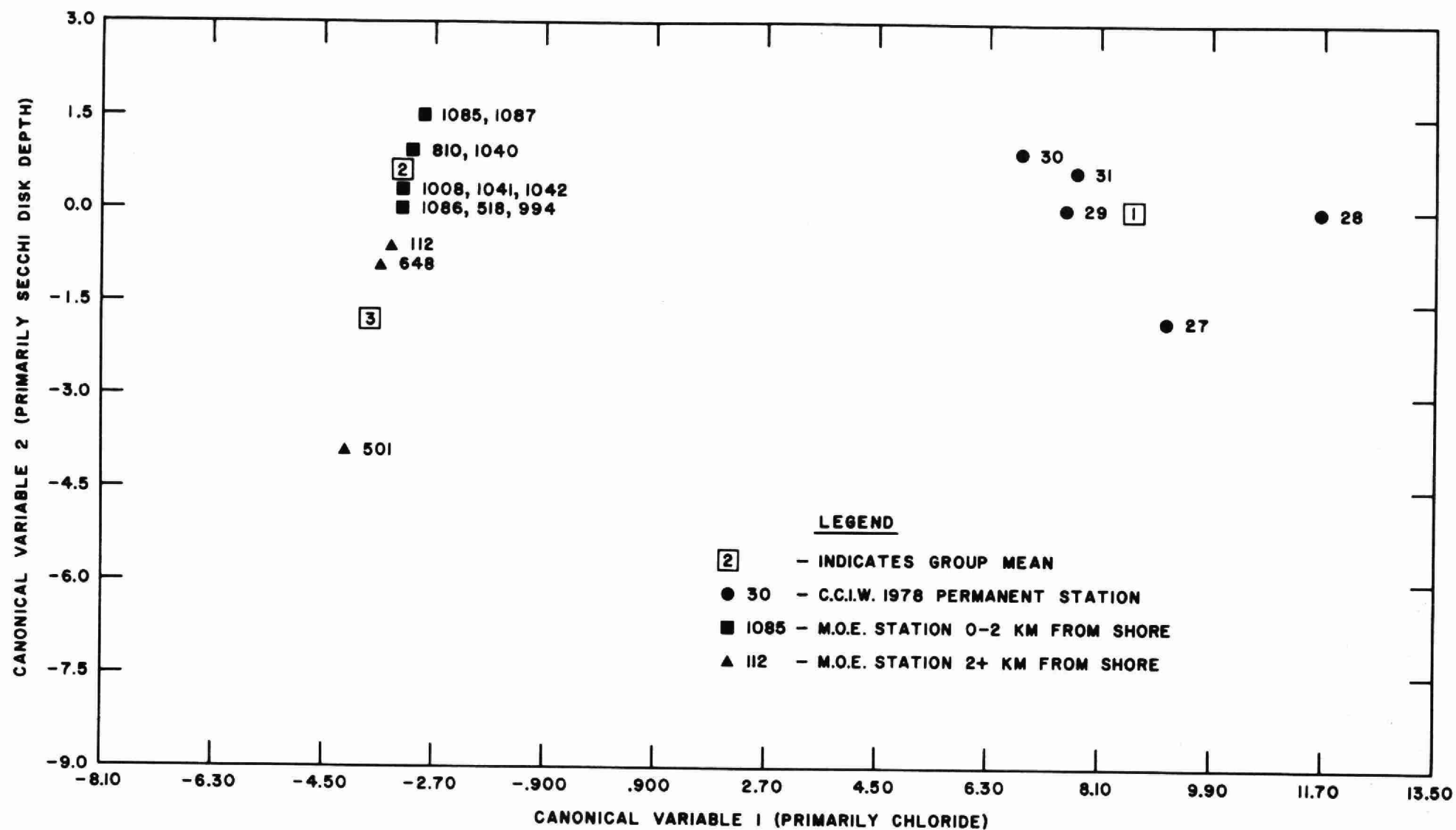


FIGURE 7 - PLOT OF FIRST TWO CANONICAL VARIABLES OBTAINED FROM DISCRIMINANT ANALYSIS.
(RESULTS FROM M.O.E. CRUISE JULY 17, 1978 AND C.C.I.W. CRUISE JULY 13, 1978).

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Publication



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